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AN ACCOUNT OF THE PROGRESS

IN

ASTRONOMY

IN

THE YEAR 1886.

BY

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presented by the author

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ASTRONOMY, FOR 1886.

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In preparing the review of Astronomy for 1886, the method and arrangement adopted by Professor Holden from 1879 to 1884 have been adhered to without essential modification. The record is intended primarily to serve as a series of notes for those who have not access to a large astronomical library, but it is hoped that the bibliography will be found useful to the professional astronomer as a reference list of technical papers.

Much assistance has been derived from the reviews and abstracts in the Bulletin Astronomique, the Observatory, Nature, the Athenæum, and other periodicals, and the writer is indebted to the directors of many observatories for the communication of information not otherwise available.

A subject-index to the review has been effected by inserting the necessary page-references in the bibliography.

DISTRIBUTION OF STARS.

Distribution of the stars in Schönfeld's Durchmusterung.—The completion of the Durchmusterung to $-23°$ of declination by Argelander's successor, Dr. Schönfeld, has given Professor Seeliger the opportunity of extending his counts of stars to a considerable portion of the southern hemisphere. Professor Seeliger's paper "Über die Vertheilung der Sterne auf der südlichen Halbkugel nach Schönfeld's 'Durchmusterung,'" has been published in the Proceedings of the Bavarian Academy of Sciences, and résumés may be found in the Bulletin astronomique (3:593–6), the Observatory (9:399), and Nature (34:627). An abstract of Professor Seeliger's previous work was given in the "Account of the Progress in Astronomy" for 1884, and his present discussion has been carried out on a plan similar to that there described.

The stars are divided into eight classes, one more than previously used, as Schönfeld has included stars of the tenth magnitude, whereas Argelander stopped at 9.5.

Schönfeld's zones begin at $-2°$, but the "counts" may be carried up to the equator by utilizing Argelander's work; the slight difference in limiting magnitude will not affect materially the result. The stars embraced in each degree of declination have been divided into groups of twenty minutes in right ascension, though only the sums for each forty minutes have been published.

The number of stars in each of the eight classes is as follows:

Classes.	Magnitudes.	A. Number of stars $-2°$ to $-23°$.	B. Number of stars $0°$ to $-23°$.
I	1 - 6.5	1,265	1,369
II	6.6- 7.0	1,276	1,347
III	7.1- 7.5	1,828	1,952
IV	7.6- 8.0	3,516	3,800
V	8.1- 8.5	7,601	8,313
VI	8.6- 9.0	18,633	20,509
VII	9.1- 9.5	55,565	61,540
VIII	9.6-10.0	43,896	43,896
Total		133,580	142,726

The numbers in column A comprise Schönfeld's stars only; column B includes Argelander's stars, from $0°$ to $-2°$, for the first seven classes: to complete Class VIII about 3,600 should be added. The number of stars thus counted in the "Southern Durchmusterung" proper is, therefore, 133,580, and adding to this 79 objects which are classed as nebulæ or variables, there results the grand total, 133,659.

In order to investigate the influence of the Milky Way on the distribution of these stars, Professor Seeliger proceeds, as in his former paper, to form the "gradient," which expresses for each class the rapidity of increase in the number of stars as we approach the Milky Way. Comparing the values of the gradient with these found for Argelander's Durchmusterung, it is seen that, as far as Schönfeld's work can be considered typical of the southern hemisphere as a whole (it must be remembered, however, that it only embraces one-third thereof) the influence of the Milky Way on stellar distribution, at least for stars down to the eighth magnitude, appears to be less marked for the southern than for the northern hemisphere. But it may well be that, especially in the higher classes of stars, local and accidental irregularities are the cause of this apparent difference. With regard to the question as to which hemisphere is the richer in stars, it appears that there is no decided difference shown by the two surveys under consideration. When Argelander's numbers are corrected so as to be comparable with Shönfeld's, taking stars down to the ninth magnitude, inclu-

sive, the totals are, for the former, 34,324, and for the latter, 34,119, a difference which may reasonably be attributed to accidental circumstances.

The whole discussion of the distribution of the stars will no doubt be much facilitated by the application of photography.

A writer in L'Astronomie has concluded that the total number of stars in "our nebula"—on the assumption that the combined light of the stars is equal to one-tenth that of the full moon—must be sixty-six thousand million.

NEBULÆ AND STAR CLUSTERS.

New nebulæ.—Two lists, embracing 476 new nebulæ discovered with the 26-inch equatorial of the Leander McCormick Observatory, have been published in the Astronomical Journal (7: 9, 57) by Professor Stone. The observers were Professor Stone himself, Mr. Leavenworth, and Mr. Muller. In the earlier observations Herschel's abbreviations were used to designate brightness and size. Afterwards numerical magnitudes were employed to indicate brightness, assuming that the faintest nebula visible in the 26-inch refractor with power 167, is 16.3, that being the theoretical limit for stars. The magnitudes given refer to the nucleus, or, in case there is no nucleus, to the brightest part. Still later the custom was instituted of estimating the diameters of the nebulæ in fractions of the diameter of the field, and from these deducing their dimensions in minutes of arc.

Dr. Swift has published (Astron. Nachr., 115: 153, 257; 116: 33) catalogues 3, 4, and 5 of nebulæ discovered at the Warner Observatory. He states in the report of the observatory that 540 nebulæ have been discovered up to January 1, 1887. Mr. Muller has found that fifteen of "Catalogue No. 5" have already been announced by other observers. (Sid. Mess., 6: 83.)

The Pleiades.—M. Rayet, in order to test the penetrating power of the 14-inch Bordeaux equatorial, has made a revision of Wolf's chart of the Pleiades, and has determined accurately the positions of 143 stars, most of them of the fourteenth or fifteenth magnitude, not given by Wolf.

The Henry brothers have also compared their photographs of the Pleiades with Wolf's chart, and have been able to detect 1,421 stars where Wolf shows but 625, the telescopes used being of nearly the same aperture. In order to avoid errors which might arise from impurities in the photographic plate, three exposures, of an hour each, were made, and the plate was shifted between exposures, so that three images of each star are obtained, forming an equilateral triangle. Stars as faint as the sixteenth magnitude are depicted. All the stars of Wolf's chart are found upon the photograph except ten, and these the Messrs. Henry have been unable to find in the sky. A number of faint companions have been detected close to several of the brightest stars of the group,

and in several cases where M. Wolf has observed a faint companion to a bright star, the photograph has shown that the magnitude of the former was underestimated. One of the advantages of photography seems to be that it brings out faint objects which are lost to the eye, on account of their proximity to bright stars. Besides the nebula discovered about Maïa, a nebulous streak has been seen near Electra, and details of the Merope nebula have been made out, which had not been recognized before, except by Common.

Dr. Weiss has expressed a strong suspicion that all of the region to the north and west of Alcyone is a vast nebula, only the brightest portions of which are shown by our best telescopes. He recalls a statement by Schmidt in 1863, that a small planet seemed to lose a part of its light in traversing the region between Alcyone and Electra.

Dr. Kammermann has been able to see the new Maïa nebula with the 10-inch refractor of the Geneva Observatory by masking the bright star, and by using a special eye-piece provided with diaphragms, and a plate of uranium glass, to increase the intensity of the chemical rays.

A paper by Dr. Elkin upon "A comparison of the places of the Pleiades as determined by the Königsberg and Yale College heliometers" was read at the Buffalo meeting of the American Association. Provisional results show unquestioned change of position with reference to η Tauri since 1840. Most of the brighter stars of the group, as shown by Newcomb in his "Standard Stars," go with η Tauri, but among the smaller stars there are departures from this community of proper motion. Professor Pickering has pointed out that the agreement of the spectra of certain of these stars strongly confirms the probability of their physical connection.

ASTRONOMICAL CONSTANTS.

Lœwy's method of determining the elements of refraction.—M. Lœwy has elaborated his method of determining the elements of refraction by means of a reflecting prism placed in front of the object-glass of an equatorial, and has submitted the problem to a careful mathematical analysis in several papers communicated to the French Academy. The full titles of these important papers are given in our "biobligraphy." Dr. Gill speaks very highly of the plan, and has suggested some modifications of the details which he thinks would increase the ease and accuracy of observations.

Oppolzer's astronomical refraction.—The late Dr. von Oppolzer published in the Transactions of the Imperial Academy of Sciences, of Vienna, a paper containing a theoretical discussion of the problem of astronomical refraction followed by numerical tables intended to facilitate the practical application of the results at which he arrived. When the approximations are carried far enough, the method seems capable of giving results of great accuracy, even for large zenith distances.

A correction for gravity in the use of refraction tables.—Prof. Cleve-

land Abbe has directed attention to a neglected correction in the use of refraction tables, which appears as a function of the latitude. Thirty inches of mercury in the barometer at the equator indicate a less density of the atmosphere than 30 inches at the poles, consequently the barometer readings should be corrected for differences of latitude. This is accomplished by simply adding to the formula one more factor for gravity. Professor Abbe shows that the difference of latitude between Pulkowa and Washington makes a difference of 0″. 1 in the refraction at 45° zenith distance, and increases with the zenith distance. We have here a partial explanation, at least, of systematic differences in declination shown by different catalogues.

Correction for differential refraction in declination.—Professor McNeill, of Princeton, has devised (Astron. Nachr., 114:385) a method of correcting micrometer observations for refraction, applicable to the diagonal-square micrometer, the ring micrometer, and others of the same class. The correction to the observed difference of declination is not determined by a special separate computation, but the true difference is directly determined, the corrections being applied to the logarithms in the course of the computation. Tables are given which will be found very useful to observers.

In a "Zusatz" to this communication, Dr. Krueger gives a résumé of differential refraction formulæ for ring and filar micrometers.

M. Radau suggests (Bull. astron., 3:373) that Professor McNeill's principal table may be replaced by a simple graphical table which will give at a glance the correction sought.

The diurnal nutation of the earth's axis.—M. Folie, about three years ago, submitted to the Paris Academy a theory of the diurnal nutation of the earth's axis, based upon the assumption that the earth has a fluid nucleus; and he has recently given (Compt. Rend., Dec. 13, 1886) some practical illustrations of his formulæ. These formulæ contain two constants to be determined by observation: the constant of diurnal nutation itself, and the longitude, referred to an initial meridian. Very accordant results are obtained from the rather meager observational material available, the value of the diurnal constant being about 0″.2. The new correction applied to a series of observations of Polaris made at Pulkowa, smooths out the discordant observations in a most surprising manner. Further investigation of this subject seems highly desirable.

An abstract of the paper read by Prof. J. C. Adams at the Philadelphia meeting of the American Association, September 11, 1884, "On the general values of the obliquity of the ecliptic, and of the precession and inclination of the equator to the invariable plane, taking into account terms of the second order," has appeared in the Observatory for April, 1886, vol. 9, p. 150–154.

STAR CATALOGUES, ETC.

Schönfeld's Southern Durchmusterung (1855.0).—This catalogue contains the approximate positions of 133,659 stars between 2° and 23° of south declination—that is, all stars between those limits down to the tenth magnitude. It carries Argelander's "sweeps" as far south as the latitude of Bonn will permit, and is on essentially the same plan as the Northern Durchmusterung. In the details of the work, however, several improvements have been made: Instead of Argelander's little 3-inch glass, magnifying nine times, Dr. Schönfeld used a telescope by Schröder of $6\frac{1}{4}$ inches aperture with a magnifying power of twenty-six, and with the field slightly illuminated. The width of the zones was $1\frac{1}{2}$°, instead of 2°, the width of the older zones. This involved more hours of observation, but the accuracy of the work and the certainty of catching faint stars were increased, since the observer was not obliged to take in everything up to the limit of visibility. A further advantage which the Southern Durchmusterung possesses is that Dr. Schönfeld has himself made all of the observations and revisions, so that the work is more homogeneous than the Northern Durchmusterung. The observations were begun, after some preliminary experiments, on the 6th of June, 1876; by the 28th of March, 1881, the zones had all been observed for the second time. There are, including sixteen zones subsequently re-observed, 363,922 observations, all reduced to 1855.0. The revision, also by Dr. Schönfeld and with the same instrument, embraced 5,700 positions, and was finished between April, 1881, and March, 1884.

From the summary of the stars in each square degree it appears that the Southern Durchmusterung is richer in stars than the Northern, in the ratio of 1.21 to 1. The fainter stars (under the ninth magnitude) are much more thoroughly observed than before, the limit being the tenth magnitude instead of 9.5, that adopted by Argelander. The probable error of a single estimation of magnitude for stars of the 9.5 magnitude is only 0.11 magnitude, and for the seventh magnitude, 0.26 magnitude. The charts accompanying the catalogue contain an hour each in right ascension.

The Argentine General Catalogue.—The observations from which this catalogue was formed were made with the meridian circle of the Cordoba Observatory during the years 1872–'80. During these years the zone observations were the chief object of attention, and the catalogue contains the places of 32,448 stars whose positions were more elaborately determined during the progress of that great work, and constitutes an addition to our knowledge of southern stellar positions of perhaps not less importance than the Cordoba Zone Catalogue. The General Catalogue gives the positions for the epoch 1875.0 of most of the southern stars brighter than magnitude $8\frac{1}{2}$, the deficiencies in this respect being chiefly found north of the parallel of 23°, at which the zone begins. These omissions will be of comparatively small importance,

inasmuch as the Durchmusterung of Professor Schönfield comprises all the southern stars within this region, while accurate determinations of the brighter ones will have been made in the re-observation of Lalande's stars now nearly completed at the Paris Observatory.

Pulkowa catalogue of 3,542 *stars for* 1855.0.—Volume VIII of the Pulkowa Observations is to contain two catalogues of stars deduced from observations made with the meridian circle from 1840 to 1869. The first of these—the one that has just been published—contains, with the exception of the Pulkowa fundamental stars (observed with the transit instrument and vertical circal), all Bradley's stars between the north pole and 15° south declination, and also a comparatively small number of other stars down to the sixth magnitude, inclusive, given in the *Uranometria Nova* of Argelander, in the same part of the sky. A few fainter stars have also been taken into the catalogue. The whole work has been in the hands of Dr. Backlund. (Bull. astron., November, 1886.)

Kam's catalogue of "Nachrichten" stars for 1855.0.—"Dr. N. M. Kam of Schiedam has published in Verhandelingen der Koninklijke Akademie van Wetenschappen, Deel. 24 (Amsterdam), a star catalogue compiled from the places of stars determined by meridian observations, which have been extracted from volumes 1 to 66 of the Astronomische Nachrichten, and reduced to the epoch 1855.0. The positions of the stars contained in this catalogue were determined in connection with observations of planets and comets, and it was in compliance with Argelander's express desire that the work of collecting them and reducing the positions to a common epoch was commenced by Hoek, then director of the Utrecht Observatory. Dr. Kam, who was Hoek's assistant, continued the work after the death of the latter, and has at length been able to publish his results. The principal catalogue contains the completely determined places of 4,350 stars, and is followed by two subsidiary catalogues, the first giving the places of 236 stars, and the second those of 335 stars; all of the latter, however, are incomplete, *i. e.*, the place is given in one element only. The catalogues are followed by a comparison of the places of the stars contained in them with their places as given in the Bonn Durchmusterung, or, for stars south of — 2° declination, with other authorities. Notes on proper motions, corrigenda, etc., are appended, which are of considerable interest and value." (Natnre, June 3, 1886.)

Romberg's catalogue of "Nachrichten" stars (1855.0).—Herr Romberg, of the Pulkowa Observatory, has compiled a catalogue of about 8,000 stars extracted from the Astronomische Nachrichten, volumes 67 to 112, and his work now appears as Publication XVIII of the Astronomische Gesellschaft. This is a continuation of a similar compilation (Pub. VIII, Astron. Gesellsch.), by Schjellerup, from the first sixty-six volumes of the Nachrichten, and is prepared on much the same plan. The stars have appeared in the Nachrichten as comparison stars for planets, comets, etc., and have been collected by Romberg and reduced to 1855.0.

Right ascensions are given to seconds of time, declinations to the nearest tenth of a minute of arc. The catalogue proper is followed by several useful pages of notes.

Edinburgh catalogue.—Prof. Piazzi Smyth has given in volume XV of the Edinburgh Astronomical Observations the results of observations made from 1833 to 1872 upon some 3,890 B. A. C. stars, reduced to the epochs 1830, 1870, 1880, and 1890. The catalogue begins with $4^h\ 0^m$ of right ascension, the first four hours having appeared nine years ago as volume XIV. The notes contain information in regard to the proper motion, color, or duplicity of the stars.

Second Armagh catalogue of 3,300 *stars for* 1875.0.—After the completion of the observations of Bradley's stars, the results of which were embodied in the catalogue commonly known as the "Armagh Catalogue," Dr. Robinson formed the plan of re-observing a number of stars from Lalande's "Histoire céleste," occurring in Baily's catalogue. Observations were commenced in 1859 with the 3¾-inch mural circle and transit, but were stopped after 1860 in order to change the mural into a 7-inch transit circle. Work was resumed in 1863, and continued with more or less regularity till 1883. The right ascensions of this catalogue depend on the standard stars of the "Nautical Almanac;" the north polar distances upon observations of the nadir. Dr. Dreyer, who succeeded Dr. Robinson in 1882, found from 400 observations of 80 stars between 30° and 100° N. P. D., that the probable error of a single observation in right ascension was $\pm 0^s.081$, (the single errors having been multiplied by $\cos \delta$); and in north polar distance $\pm 0''.85$. For systematic errors Armagh has been compared with Glasgow, and, indirectly through the latter, a comparison is obtained with Auwers' fundamental system. From this comparison it appears that the north polar distances are in fair agreement with Auwers' catalogue, while the right ascensions show considerable discordances.

Reliability of the star-places of Auwers' Fundamental Catalogue.—Mr. Chandler, having pointed out the possibility of error in the places of certain stars (Observatory 8: 387), as given in the Berlin "Jahrbuch," Herr Auwers has been induced to publish (Astron. Nachr., 114: 1–20) some valuable and interesting remarks on the reliability of the places of his Fundamental Catalogue (Pub. d. astron. Gesellsch., 14), from which those given in the Berlin "Jahrbuch" are derived. Herr Auwers explains the provisional character of the data on which some of his star-places depend, and repeats in a more definite manner what he has already said on the subject in Publication XIV. In fact the proper motions adopted for some of the stars are merely provisional, as has been pointed out in the introduction to the catalogue. The proper motions employed have been, as a rule, obtained from a comparison of Bradley's places with those of Greenwich, 1861, and in those cases in which Bradley has only one observation, or observed the star in one element only, the proper motion is given to one decimal place less than usual. The reader

is thus put on his guard, and knows that he should use the places of certain stars with circumspection. Herr Auwers thinks that it would be premature to attempt any correction of the catalogue places before the completion of the general revision, which has been undertaken by the observers of the zones and by the Pulkowa astronomers. He, however, takes this opportunity of publishing the results of investigations he has made as to the mean errors of the different catalogues employed in the formation of the Fundamental Catalogue, viz, Pulkowa, 1845 and 1865; Greenwich, 1861 and 1872; Cambridge (U. S.), 1872; Leipzig, 1868; and Leiden, 1868, for the principal stars; and in addition to these, Pulkowa, 1871, for the supplementary stars.

The following are, in the mean (for declination — 10° to + 90°), the mean errors, referred to the unit of weight, for the principal stars:

	P. 1845.	P. 1865.	G. 1861.	G. 1872.	C. 1872.	Lp. 1868.	L. 1868.
R. A. ($\varepsilon \cos \delta$) . .	$0^s.040$	$0^s.063$	$0^s.038$	$0^s.032$	$0^s.031$	. . . .	. . . .
Decl. (ε)	$0''.51$	$0''.61$	$0''.55$	$0''.52$	$0''.86$	$0''.46$	$0''.58$

And for the supplementary stars:

	P. 1845.	P. 1871.	G. 1861.	G. 1872.	C. 1872.	Lp. 1868.	L. 1868.
R. A. ($\varepsilon \cos \delta$) .	$0^s.043$	$0^s.057$	$0^s.053$	$0^s.034$	$0^s.035$	. . . .	. . . .
Decl. (ε)	. . . .	$0''.73$	$0''.64$	$0''.52$	$0''.89$	$0''.72$	$0''.52$

We have then, finally, for mean error of the right ascensions $0^s.033$ (for supplementary stars $0^s.042$), and for the declinations $0''.59$ (for supplementary stars $0''.67$). The somewhat considerable difference in the results for principal and for supplementary stars arises from the circumstance that Herr Auwers gave relatively too much weight to Pulkowa 1871, at least for the right ascensions. For the catalogue-places, the mean errors are $0^s.009$ and $0''.14$ in R. A. and Decl., respectively, for the principal stars, and $0^s.026$ and $0''.19$ for the supplementary stars; where the mean error in R. A. refers to the total number of stars between — 10° and + 50°. At the present time, in Herr Auwers' opinion, the probable error of the star-places is not greater than $0^s.02$ in R. A. (for moderate declinations), and $0''.15$ in Decl. (Observatory, 9:202, May, 1886.)

In response to a suggestion by Dr. Gill, a number of astronomers have expressed their willingness to co-operate in the systematic observation of stars which have been used in comet comparisons, faint stars whose occultations have been observed, zones of stars used for scale or screw values, or stars that have been used for geodetic purposes. Among the observatories ready for this work are, the Cape of Good Hope, Neuchâtel, Bruxelles, Cointe, Taschkent, and Cordoba.

Professor Holden, while at the Washburn Observatory, compiled a list of all published corrections to his star catalogues, inserting the errata in the bodies of the books themselves. The original sources from which the errata were copied are given in the fourth volume of the Publications of the observatory. The value of this list will be appreciated by all astronomers who have occasion to make use of star catalogues.

The catalogue of stars of the British Association has been advertised recently at 170 mark, or about $43.

STELLAR PARALLAX.

Prof. A. Hall has given in Appendix II to the Washington Observations for 1883 the results of recent observations made with the 26 inch equatorial to determine the parallaxes of α Lyræ, 61 Cygni, 40 (o^2) Eridani, and 6 β Cygni. The results are as follows:

Date.	Star.	Parallax.	No. of observations.
		$''$ $''$	
February 23, 1883, to March 4, 1884	40 (o^2) Eridani	$+0.223 \pm 0.0202$	30
July 31, 1883, to April 15, 1886	6 B Cygni	-0.021 ± 0.0077	54
May 24, 1880, to July 2, 1881	α Lyræ	$+0.134 \pm 0.0055$	128
October 24, 1880, to January 26, 1886	61 Cygni	$+0.270 \pm 0.0101$	101

Dr. W. Schur has published in the Astronomische Nachrichten (vol. 114, p. 161), a discussion of the parallax of the double star ψ^5 Aurigæ from measures of position, angle, and distance made with 6-inch Strassburg refractor, in 1883–'85. The final value for the parallax of the fainter (ninth magnitude) star is $+ 0''.111 \pm 0''.034$. "Herr Schur thinks that he is justified in asserting that the parallax of this star is at least $0''.1$—a remarkable result, considering the fixity of the object."

40 (o^2) *Eridani.*—Mr. J. E. Gore, using Professor Hall's parallax, $0''.223$, has obtained by means of elements which he has computed, the following figures:

Distance of 40 Eridani from the earth	924,955
Mean distance between the components, B C	26.86
Sum of masses B C / Sun's mass = 1	1.003

The unit of distance is the mean distance of the earth from the sun.

DOUBLE STARS.

Two recent papers on personal equation in double-star observations will be found of especial interest to those engaged in this class of work. The first paper forms the subject of a thesis by M. Bigourdan, of the Paris Observatory, submitted for the degree of doctor of physical

science. M. Bigourdan reviews the work of others in this field, gives a description of apparatus which he has devised for investigating the problem by means of artificial stars, and deduces his own personal equation from a large number of measures made with this apparatus. He finds that his personal equation is not affected by the position of the eyes with respect to the line joining the stars nor by the altitude; the brightness of the stars, on the other hand, does affect his measures.

The second paper referred to is by Mr. H. C. Wilson, formerly of the Cincinnati Observatory, and is published in the Sidereal Messenger (vol. 5, pp. 174, 211). Mr. Wilson gives an interesting sketch of the history of the subject, together with an investigation of his personal errors, obtained from observations made between 1882 and 1886, with the equatorial of the Cincinnati Observatory. He finds that his measures, both of position angle and of distance, are slightly influenced by the inclination of the head.

Spectroscopic method of determining the distance of a double star.—Mr. A. A. Rambaut, of the Dublin Observatory, in a paper communicated to the Royal Irish Academy on May 24, 1886, discusses at some length the possibility of determining the distance of a double star by measures of the relative velocities of the components in the line of sight. Dr. Huggins having demonstrated that it was practicable to measure the rate of approach or recession of a star, it was seen that it would be at least theoretically possible to determine the distance of a star by this method. Mr. Rambaut's critical examination of the conditions of the problem shows however that the method can have but little practical application.

Orbits of double stars.—The following table gives the "period of revolution" in years, and "semi-axis major," in seconds of arc, obtained for a number of binary stars in recent determinations of elements:

Star.	Period.	Semi-axis major.	Computer.	Published in—
	Years.	$''$		
$O\Sigma$ 234	63.45	0.339	Gore	Astron. Nachr., 115:111.
ζ Sagittarii	18.69	0.53	...do	Month. Not., 46:444.
τ Cygni	53.87	1.19	...do	Astron. Nachr., 115:215.
40 (o^2) Eridani	139.0	5.99	...do	Month. Not., 46:291.
β Delphini	30.91	0.517	...do	Proc. Roy. Irish Acad., 2 s., v. 4, No. 5.
γ Coronæ Australis	81.78	1.885	...do	Month. Not., 46:103.
γ Coronæ Australis	78.80	1.85	Wilson	Sid. Mess., 5:251.
α Centauri	87.44	18.89	Powell	Month. Not., 46:289, 336.

VARIABLE, NEW, OR TEMPORARY STARS—COLORED STARS.

Observations of variable stars in 1885.—Professor Pickering prints in the twenty-first volume of the Proceedings of the American Academy his third annual report upon observations of variables, giving particu-

lars of nearly two hundred stars for 1885. The work has been done by co-operation. All who are willing to assist (a field-glass is sufficient instrumental equipment), are requested to send accounts of their work to the Harvard Observatory as soon as possible after the close of each year. Professor Pickering undertakes to make photometric observations of all comparison stars needed.

Mr. Espin, the special observer of the Liverpool Astronomical Society, has commenced the issue of a circular calling attention to various variable stars or stars suspected of variability.

Several interesting cases of variability have been discovered by Messrs. Chandler and Sawyer, of Cambridge. The most interesting case is a new variable of the Algol type discovered by Mr. Chandler in the constellation Cygnus (R. A. $20^h\ 45^m$; Decl. $+34°\ 14'$). The range is from 7.1 magnitude to 7.8 magnitude, the whole variation taking place in about six hours. The only doubt is in regard to the interval during which the star remains at its normal magnitude. Mr. Chandler suspects that the whole duration between two successive periods of change will be found to be about one day, twelve hours.

Gore's new variable near χ^1 Orionis (Nova Orionis).—A mass of observations by skillful observers has accumulated, and will repay a thorough study.

It seems to be clearly established that this interesting star is a simple variable, and not one of the class to which the title "temporary" can properly be applied. M. Dunér, who observed the star at intervals from December, 1885, to April, 1886, found (Astron. Nachr., No. 2755), on renewing his observations at the end of October and the beginning of November, 1886, that it had unmistakably increased in brightness in the interval, and was continuing to do so. Herr Fr. Schwab and Mr. Espin confirm this conclusion, the former having observed the star early in last July, and having found it then fainter than the twelfth magnitude. Its period would appear to be not far from one year; Herr Schwab gives it as one or two weeks longer than one year, and as ranging in brightness from the sixth magnitude to $12\frac{1}{2}$, whilst M. Dunér assigns a period of 359.5 days. (Nature.)

According to Dr. Vogel and others who have examined its spectrum, it belongs to Type III a, resembling the spectrum of α Orionis.

The new star in the great nebula of Andromeda.—Professor Seeliger has published (Astron. Nachr., No. 2710) an interesting paper containing an attempt to represent the observed variations of the light of the *Nova* in Andromeda by a formula expressing the rate of cooling of a hot sphere. Supposing that such a body has its temperature suddenly increased to an enormous extent by some shock, its brightness will of course be increased also. And assuming that the latter is proportional to the *n*th power of the temperature, and using Pogson's scale for transforming brightness into stellar magnitude, Professor Seeliger (making

some further more or less probable assumptions) deduces an expression for the magnitude of the cooling star at any time. In order to compare this formula with Herr Müller's photometric measures of the *Nova*, extending from 1885, September 2, to October 13, Professor Seeliger assumes that $n=1$, and that the epoch for which the time $t=0$, is 1885, August 27, 8^h Berlin mean time. Using quite approximate values of the constants involved in his formula, it appears that there is a good general agreement (the mean discordance being 0.11 of a stellar magnitude) between the computed and observed values. The computed magnitude corresponding to the epoch for which $t=0$, is 7.73. The fair agreement shown by this comparison induces Professor Seeliger to think that the form of the expression which he has deduced is such as would accurately represent the observations, provided that it were possible to determine the necessary constants with sufficient precision. And as there is evidence to show that the nebula in Andromeda is, partly at least, composed of a vast number of faint stars, it appears, in Professor Seeliger's opinion, not unreasonable to suppose that a collision was the cause of the sudden development of heat and light which revealed itself to us as the appearance of a "new" star.

With reference to the point thus raised by Professor Seeliger, Herr Auwers points out (Astron. Nachr., No. 2715) that the great similarity of the outburst in Andromeda in 1885 to the phenomenon observed by him in 1860 in the cluster 80 Messier in Scorpio is a strong confirmation of Professor Seeliger's views. The probability that two variable stars of such exceptional character should be projected, in one case on a close star-cluster, in the other case on an object which appears to be, in part at least, a close star-cluster, is so small that it is almost necessary to refer these outbursts to physical changes in the nebulæ in which they respectively appeared. (Observatory, April, 1886.)

Dr. Mills (Nature 33 : 440) in criticising Professor Seeliger's collision hypothesis suggests that the blazing out of the *Nova* may be merely a physico-chemical consequence of cooling; and it has been pointed out by Mr. Castell-Evans (Nature, 33 : 486) that practically the same explanation was suggested in 1878 by Prof. R. Meldola in a paper published in the Philosophical Magazine for July of that year. Professor Meldola says: "It is conceivable that in certain cases the composition of a star's atmosphere may be such as to permit a considerable amount of cooling before any combination takes place among its constituents; under such circumstances a sudden catastrophe might mark the period of combination, and a star of feeble light would blaze forth suddenly, as occurred in 1866 to τ Coronæ Borealis. In other cases, again, it is possible that the composition of a star's atmosphere may be of such a nature as to lead to a state of periodically unstable chemical equilibrium; that is to say, during a certain period combination may be going on with the accompanying evolution of heat, till at length dissociation

again begins to take place. In this manner the phenomena of many variable stars may perhaps be accounted for."

Dr. von Kövesligethy observing with a 7-inch Merz equatorial at the observatory of Baron Podmaniczky at Kis Kartal, in Hungary, announced the re-appearance of the *Nova* on September 26, 1886. From this date he found that it became more star-like, and up to the evening of October 2 both nucelus and new star were visible. From October 2 to October 17 the old nucleus was invisible. By October 23 the nucleus had assumed its normal state, but the new star was not seen. A number of telescopes were immediately turned upon the nebula, but in the main failed to detect the changes suspected. (*See* Astron. Nachr., 2750–2752.) It is probable that the object seen was one of the very faint points of light known to exist near the nucleus of the nebula.

A very complete series of observations of *Nova* Andromedæ is given by Dr. Copeland, of the Dun Echt Observatory, in the Monthly Notices for December, 1886.

Catalogue of colored stars.—Mr. W. S. Franks has presented to the Royal Astronomical Society a catalogue (not printed, apparently) of 1,730 colored stars situated between the pole and -20° of declination, and including all stars down to the 6.–5 magnitude. The introduction to this catalogue, giving a tabular analysis of the colors recorded, is published in the Monthly Notices for April, 1886.

We should mention also a list of thirty-one prominent colored stars of the southern hemisphere published by Mr. A. S. Williams in the Astronomical Register for October.

Mr. Chambers stated at the meeting of the Royal Astronomical Society on March 12, 1886, that he was preparing a catalogue of red stars.

STELLAR PHOTOMETRY.

Photometric observations at Harvard College Observatory.—Professor Pickering, in his annual report, states that 59,800 separate photometric comparisons were made with the meridian photometer in 1886. The instrument has been found to give entire satisfaction both in the accuracy and the rapidity of its work. Various tests have been applied to detect the presence of systematic errors, but so far with negative results. "A comparison of the seven hundred stars common to the observations of Wolff, Pritchard, and the Harvard Photometry, showed that our results differed on the average from Wolff, after allowance for systematic differences, by 0.140 of a magnitude; from Pritchard by 0.145; while Wolff and Pritchard differed from each other by 0.192. A comparison of the fifty five stars proposed by Professor Pritchard as standards, and measured by him on several nights, showed that the average deviation from the Harvard Photometry was only 0.101. - - - A comparison between the results obtained at Pulkowa and Cambridge shows that the average deviation of a measurement of the difference in brightness be-

tween two stars observed at both places does not exceed one-tenth of a magnitude."

The principal work of the meridian photometer, the revision of the Durchmusterung magnitudes, is now approaching completion, nine-tenths of the observations having already been made. During 1887 the observing list will be extended to include stars in the first 20° of south declination.

Observations of the eclipses of Jupiter's satellites, comparison stars for variables, etc., are made with the photometer attached to the 15-inch equatorial.

A comparison of photometric methods.—Mr. S. C. Chandler, jr., presented at the Buffalo meeting of the American Association an important paper on "A comparative estimate of methods and results in stellar photometry," in which he reaches the conclusion (also reached by Dr. G. Müller, of Potsdam,—Vrtljschr. d. astron. Gesellsch., 20 : 261–267), that the photometers now in use give no advantage, in point of accuracy, over direct eye estimates of differences in magnitude made according to Argelander's well known method. With regard to accidental errors, Mr. Chandler concludes that "eye-estimates" are nearly three times as accurate as photometric measures, and he also points out that several variables have been detected and their periods and light-curves well determined by careful eye-estimates, whose whole range of brightness is no greater than the range of error in photometric observations. Reference should be made to Mr. Chandler's paper in the Astronomische Nachrichten, vol. 115, p. 145, merely an abstract of his communication having been published in the Proceedings of the American Association.

A proposed new catalogue of magnitudes of southern stars.—Mr. E. F. Sawyer, of Cambridge, has been at work since 1882 upon a determination of the relative magnitude of the stars included between the equator and 30° of south declination, and not fainter than the seventh magnitude. The observations are made with an opera glass (magnifying two and a half times) put slightly out of focus. The number of stars comprised will approximate 3,500, and the average number of observations for each star will be about three and one-half. Mr. Sawyer finds from 593 stars, each observed twice, that the average difference between two independent determinations of a magnitude of a star is 0.112 of a magnitude, which corresponds to a probable error of a single observation of ± 0.065. It is expected that the work will be completed and ready for publication within a year.

STELLAR SPECTRA.

Photographic study of stellar spectra at Harvard College Observatory.—Professor Pickering has announced in his annual report an extensive investigation in stellar spectra, by means of photography, undertaken

at the Harvard Observatory. Provision has been made by Mrs. Draper for meeting the expenses of this work, as a memorial to her husband, the late Dr. Henry Draper.

Three researches are now in progress.

The first includes a general survey of stellar spectra. Each spectrum is photographed with an exposure of not less than five minutes, and these photographs generally exhibit the spectra of all stars brighter than the sixth magnitude with sufficient distinctness for measurement. The greater portion of the sky north of $-30°$ has been surveyed in this work, which will be repeated during the coming year. One hundred and fifty-one plates have been measured and 5,431 spectra examined and classified. Of these 4,148 have been identified and the name and position of the corresponding star entered opposite each. The completed work will form a catalogue probably containing three or four thousand stars, each photographed on several plates.

The second research relates to a determination of the spectra of the fainter stars. Each photograph taken in the course of this research receives an exposure of one hour, so that the spectra of all the stars not fainter than the eighth or ninth magnitude, and included in a region ten degrees square, are represented upon the plate. On fifty-eight plates 2,416 spectra have been measured, and of these 2,359 have been identified.

In both of these investigations the 8-inch Bache telescope has been employed.

The third research relates to a more careful study of the spectra of the brightest stars. For this work Mrs. Draper has lent the 11-inch photographic lens employed by her husband. She has also furnished an admirable mounting for the instrument and a small observatory to contain it. Two prisms have been constructed to place in front of the object-glass, the large one having a clear aperture of 11 inches square and an angle of nearly 15°, the other being somewhat smaller. The preliminary results attained with this apparatus are highly promising.

A recent photograph of the region in Cygnus where four stars were known, exhibiting the interesting peculiarity of bright-line spectra, brought out four more spectra of the same kind. One of these is the comparatively bright star P Cygni, in which bright lines, apparently due to hydrogen, are distinctly visible. This phenomenon recalls the circumstances of the outburst of light in the star T Coronæ, especially when the former history of P Cygni is considered. According to Schönfeld, it first attracted attention as an apparently new star in 1600, and fluctuated greatly during the seventeenth century, finally becoming a star of the fifth magnitude, and so continuing to the present time. Another of the stars shown by the photograph to have bright lines is DM. $+ 37°$, 3821, where the lines are unmistakably evident.

ASTRONOMICAL PHOTOGRAPHY.

The improvements in astronomical photography during the past two years, following the introduction of the modern dry plates, have attracted wide-spread attention, and the great merits of the new method scarcely call for any exaggeration in order to establish photography permanently as a means for astronomical research. We find Greenwich, Harvard, Paris, Cape of Good Hope, and Lick taking steps to make stellar photography a part of their routine work, and arrangements have been made by Admiral Mouchez for holding an international conference at Paris in April, 1887, for the purpose of elaborating a plan of co-operation in photographing the whole sky. It is hoped that ten or twelve observatories will be ready to co-operate and that all will be supplied with instruments of the same power, so that the work will form a homogeneous whole. It will require 11,000 plates of 4° each to cover the sky, and ten years will probably be necessary for the completion of the undertaking.

Stellar photography at the Paris Observatory.—An article in Nature (May 13, 1886), which gives a wood-cut of the apparatus used by the Messrs. Henry, gives also the following table of the time of exposure required (with the Monckhoven gelatino-bromide plates) to obtain stars of different degrees of brightness:

Magnitude.		Time of exposure.
1		$0^s.005$
2		0 .013
3		0 .03
4		0 .08
5		0 .2
6	The limit of magnitude visible to naked eye	0 .5
7		1 .3
8		3
9		8
10	Mean magnitude of the asteroids	20
11		50
12		2^m 0
13		5 0
14		13 0
15, 16	The smallest stars visible in large telescopes	1^h 23 0

These figures represent a minimum. To secure good reproductions on paper the time of exposure would have to be increased threefold. A two hours' exposure gives stars much fainter than Herschel's *debilissima*.

The Henrys have successfully photographed the clusters in Hercules, Sobieski, Ophiuchus, and Perseus, and the major planets. They have obtained the trail of an eleventh-magnitude asteroid—a fine line among the stellar points. The new method seems well adapted, also, to the search for a trans-Neptunian planet.

The observatories at Algiers and Rio Janeiro are to be supplied with instruments similar to those at Paris, and an equatorial coudé of 0.6 meter (24 inches) apertue provided with a photographic objective is to be constructed for the Paris Observatory, to test the adaptability of this form of instrument for photographic work.

Stellar photography at Harvard College Observatory.—Professor Pickering's investigations, which were briefly referred to in last year's report, have been published in full in the Memoirs of the American Academy (vol. 11, pp. 179–226). His paper contains a sketch of the history of the subject, description of the apparatus, discussion of theoretical considerations, and some results obtained in the three departments of "star-charting, photographing star trails, and spectrum photography." His work on the photography of stellar spectra we have already alluded to in the present review.

In the report of the Harvard Observatory for 1886 it is stated that the investigation in stellar photography undertaken with the aid of the Bache fund is now nearly completed. The principal results obtained include photographs of the entire sky north of — 30°, on which all stars bright enough to leave trails without the aid of clock-work are depicted. One series of plates exhibits the effect of atmospheric absorption on nearly every night of observation for a year, and among the miscellaneous observations may be mentioned some experiments in the application of photography to transit instruments, which showed that the accidental errors did not reach one-half of those affecting eye-observations. Various photographs were taken of the nebula of Orion to show the relative brightness of different portions of this object. The nebulæ in Andromeda, in Lyra, and in the Pleiades were also photographed. An attempt was made to photograph a satellite of Jupiter while undergoing eclipse, and thus to determine the time of this phenomenon.

Astronomical photography at the Lick Observatory.—In a very interesting article upon astronomical photography, published in the Overland Monthly for November, 1886, Professor Holden thus summarizes the facilities of the California observatory for investigations in this field: "We expect to have a photographic objective as large as 36 inches in aperture, if the glass for this can be obtained. This will be mounted in the most perfect manner, and we shall employ the 12-inch Clark telescope, now at the observatory, as a pointing telescope for the large objective. The 12-inch telescope will be mounted alongside the other. An electrically-controlled driving clock will keep the two telescopes accurately directed during the exposure. Our objective will collect nine times the light of any other photographic telescope now made. - - - The focal length of the combination will be about 580 inches, and 1″ on the plate will therefore be 0.002 inch. This is a quantity whose $\frac{1}{100}$ part can easily be measured. A single exposure will give us a map of the sky comprising four square degrees on a plate 24 by 24 inches. - - - The sun's image unmagnified will be 6 inches in diameter; a large sun-spot will be the size of one's finger-nail. - - - The photographs of the moon in the focus of the Lick equatorial will be 6 inches in diameter, and will probably stand an enlargement of twelve times, so as to be 6 feet finally."

Stellar photography at Cordoba.—Dr. Gould, in a paper read at the Buffalo meeting of the American Association, has described the photographs taken at Cordoba from 1872 to 1882. About seventy southern clusters and more than a hundred double stars were repeatedly photographed. Some sixteen plates of the Pleiades and five of Præsepe were obtained; the total number of photographs being somewhat less than thirteen hundred. Dr. Gould lays great stress on the necessity of promptly converting the photographs into a permanent numerical record: and considerable uneasiness is aroused by the discovery that the collodion or gelatine films are readily detached from the plates. Some progress has already been made in the reductions, under Dr. Gould's immediate supervision at Cambridge.

Pritchard's "Researches in stellar photography."—In a paper with the foregoing title, read at the meeting of the Royal Society, May 27, 1886, Professor Pritchard gives an account of a number of photographs of the Pleiades which he has submitted to a critical examination, with the following objects in view:

(1) To ascertain, by means of definite and accurate measurement, the relation between the diameter of a star-disk impressed on a photographic plate with a given exposure, and its photometric magnitude; a simple formula seems to connect the two. (2) To ascertain whether the photographic plate remains an absolutely accurate picture of the actual relative positions of the stars in the sky itself, and, moreover, whether these are measurable with that extreme degree of precision which is attainable with the best instrumental means. The satisfactory accordances of measures of different plates have afforded a sufficient answer to this inquiry. (3) The third subject of investigation was the relation between the areas of the impressed star-disks and the time of exposure of the plates. As far as at present appears, these areas vary as the square root of the time, though the investigation is not to be regarded as complete. Bond, in 1858, considered that the areas varied directly as the time.

In the course of his work Professor Pritchard noticed what appeared to be a distortion of the photographic film on a small portion of the plate, and he detected a somewhat similar distortion upon one of eight plates of 61 Cygni and neighboring stars. He has hopes that in the course of a year the parallax of certain stars will be re-determined by photography, even to a greater degree of accuracy than has hitherto been achieved by direct instrumental application.

Professor Harkness has suggested that great increase in the accuracy of transit observations of the sun would be gained by inserting a sensitive photographic plate just behind the wire system of the instrument, and making an instantaneous exposure at the time of the sun's transit. This would avoid the disturbance of adjustments of the instrument arising from the exposure to the sun for several minutes, which is necessary in the present mode of observing. Stars would be observed and

the instrumental constants determined by using the eye-piece in the usual way.

COMETS.

Professor Bredichin in continuing his researches upon the mathematical theory of comets has re-determined the repulsive forces which produce the tails of different types. Making use of some forty comets in his discussion, he has found for tails of type I, a mean value, $1-\mu = 14$; but the comet of 1811, by far the most favorable for the determination of the repulsive force of this type, gave 17.5, and this represents quite well the tails of other comets. In this type the initial velocity g varies from 0.1 to 0.34, the mean being 0.23 (0.1=1.9 miles per second, about). In type II the forces vary from 0.5 to 2.2, and the initial velocities from 0.03 to 0.07, mean 0.05. For the axis of the tail $1-\mu=1.1$. In type III the repulsive forces lie between 0.1 and 0.3, and the velocities between 0.01 and 0.02.

Dr. Holetschek's investigation upon the conditions of visibility of a comet have been followed up by Dr. W. Meyer, who finds that if the great comets of 1843, 1880, and 1882 had reached perihelion in May they would have escaped unobserved. The orbit of the comet seen during the total eclipse of May 16, 1882, must have been very much like that of the comet which appeared four months later (1882 II); it seems, indeed, that the observed position can be represented to half a degree by the elements of the September comet, merely changing the time of perihelion of the latter and fixing it for the 17th of May. The ephemeris computed by Dr. Meyer with these elements shows very plainly why the Sohag comet could not be found after the eclipse, or had not been detected before; it was too faint when in a position favorable for observation. The comet is probably one of a regular stream of comets with small perihelion distance, such as 1843 I, 1880 I, 1882 II. If the orbits of the comets of 1843 and 1880 were sufficiently alike in other respects, the failure in repeated returns would be no objection to their identity, for if the returns have taken place in the month of May, the comet must have been invisible. A revolution in thirty-seven years is hardly to be reconciled, however, with the observations of 1843. and for the great comet of 1882 Frisby has found a period of seven hundred and ninety-four years.

Mr. Monck, in the Observatory for August and September, brings out some interesting statistics in support of his view that there exists a sort of "companionship" among comets—that is, cases in which the elements show a striking similarity; but it is improbable that the bodies are identical. Several of the comets of short period exhibit a family likeness which can hardly be attributed to their capture by Jupiter unless they previously formed members of a system. The question derives further interest from its bearing upon meteoric showers, for, if a family of comets can be supposed to be accompanied by a

family of meteors, a shower from nearly the same point might continue for a considerable time, giving rise to stationary radiants to which Mr. Denning has called attention.

It may not be out of place here to point out the value of physical observations of cometary phenomena—accurate observations of jets, tails, brightness, etc.—which may furnish data for testing any theories of their origin and constitution that may be put forward.

Encke's comet.—The progress of investigations upon Encke's comet may be briefly stated thus: The comet which has now been observed at twenty-four apparitions since its first discovery in 1786 "was shown by Encke to be subject to a remarkable decrease in the length of its period, a decrease which could not be accounted for by the attractive force of the sun and planets. Encke surmised that this was produced by the effects of a resisting medium. His calculations, which extended up to 1848, were continued by von Asten, who in a great measure confirmed Encke's conclusions, but found the curious anomaly that between the apparitions of 1865 and 1871, the acceleration of the mean motion which had been exhibited until the former of these years ceased to appear. Since the death of von Asten the work has been continued by Dr. Backlund, who has succeeded in showing that the apparent anomaly in question was due to an error in the formulæ of perturbations employed, and vanished when this was corrected. He was led however to the remarkable and interesting result that the acceleration of the mean motion of the comet is subject to a progressive diminution, and amounted between 1871 and 1885 to scarcely one-half of what it was between 1819 and 1865." It was reduced from 0″.104 to 0″.062. It seems very probable that about the year 1868 the acceleration underwent a change, due no doubt to some unknown modification in the physical condition of the comet.

Dr. Backlund has recently resumed his labors, which were interrupted by illness, and the first memoir, relating to the return in 1885, has just been printed; the second, treating of the comet's motion since 1865, will soon be presented to the St. Petersburg Academy of Sciences; while the third, which is in preparation, will comprise the period 1819–1868. For these researches the author has been awarded the Lalande prize of the Paris Academy.

Comet Tempel-Swift.—Bossert has given in the Bulletin astronomique an elaborate discussion of the orbit of the comet discovered by Tempel in 1869, but not recognized as periodic till its rediscovery by Swift in 1880. The period is about five and one-half years, but the comet escaped notice in 1875 and again in 1886.

Comet 1873 VII.—M. Schulhof has published (Bull. astron., 3 : 125 *et seq.*) a discussion of the orbit of this comet, and has gone into the question of its possible identity with 1818 I and 1457 I (the observations of which by Toscanelli have recently been discussed by Professor Celoria).

His conclusion, expressed with some reserve, is that 1873 VII and 1818 I are distinct bodies, with a short period of revolution but having a common origin. *Comet* 1457 I is probably identical with 1873 VII, but it is also possible that the two comets 1873 VII and 1818 I are fragments of 1457 I.

Comet 1877 VI.—Dr. Larssén, of Upsala, has completed the definitive determination of parabolic elements of the comet discovered by Coggia at Marseilles on September 14, 1877, and observed to December 10 of that year. The observations have been newly reduced and combined in five normal places, with a very satisfactory result. (Astron. Nachr. 116 : 23–26.)

Comet 1881 V.—The close agreement of the elements with those of the orbit of a comet discovered by Blanpain on the 28th of November, 1819, has led to a conjecture that the two comets are identical, although Blanpain's was computed to have a period of less than five years and Denning's of nearly nine, it being supposed that planetary perturbation had lengthened the period between the appearance of 1819 and that of 1881. It has been noticed both by Mr. Plummer and by Mr. Denning that the longitude of the ascending node of the 1881 comet corresponds almost exactly with that of the descending node of Biela's comet, which has not been seen as a comet (or rather double comet) since 1852, though it has been supposed to be connected with a very brilliant meteoric display seen on the 27th of November, 1872. The other elements of Denning's comet exhibit a remarkable agreement with those of Biela's comet; and the suggestion in question is that these comets are identical, or rather that Denning's is identical with the principal remaining portion of Biela's, which underwent violent perturbation through near approach to the earth in 1872, sufficient to lengthen its period and reverse the nodes (a necessary consequence of altering the inclination through zero). Colonel Tupman, whose calculations well confirm this theory, remarks "that on the 27th of November, 1872, it is probable that the comet was very near the earth and mixed up with the meteoric shower." The comet passed its perihelion on the 13th of September, 1881; the computed length of its period was 8.83 years, or about 3,225 days; and this was almost exactly the interval which had elapsed since the meteoric display of the 27th of November, 1872. If this theory be true, we can not expect another similarly brilliant display on that day until the year 1916, five periods of the comet's revolution in its orbit being very nearly equal to forty-four of the earth's. (Athenæum.)

Comet 1881 VIII.—Olsson finds a period of 612 years; that found by Oppenheim was 2,740 years, though Oppenheim remarks that 900 years would satisfy the observations almost as well.

Comet 1882 II.—The valuable series of observations of this comet made at the Cape of Good Hope, including the remarkable observation of the disappearance of the comet at the limb of the sun, has been published as vol. II, part 1, of the Annals of the Cape Observatory. Inter-

esting observations of the tail, accompanied by numerous sketches, are found in vol. I of the Publications of the McCormick Observatory, the observers being Messrs. Leavenworth and Jones.

Comets of 1886.—Nine comets passed perihelion in 1886; three of them visible to the naked eye. One was a well-known periodic comet returning at the appointed time, and two of the new-comers appear to be periodic, one of them identical possibly with De Vico's lost comet of 1844. Olbers's comet of 1815 was not detected, but as an uncertainty of some three years exists in the period of revolution, it may be picked up during the coming year. The Tempel-Swift comet due at perihelion on May 9 seems to have escaped notice on account of its excessive faintness. Of these nine comets, three belong to Barnard, three to Brooks, two were found by Finlay, and one by Fabry; two were discovered in 1885, one in 1887; leaving six discovered in 1886. Comet 1886 IX was picked up by three observers independently, on three successive mornings in October, showing what a careful watch is kept by comet-hunters. Warner prizes to the amount of $800 were paid for the captures.

Comet 1886 I:
=Comet *d* 1885.
=Fabry's comet.

This comet, as noted in last year's report, was discovered on December 1, 1885, at Paris. From a faint little patch of nebulosity it grew steadily in size and brightness, and on March 29, 1886, Fabry described it as having a diffused nucleus about 15″ in diameter, comparable with a star of the seventh magnitude; a tail about 20′ long and 4′ broad, was thrust out in a position angle of 325°, while the nebulosity extended about 1′.5 beyond the head. It became rapidly more prominent, and on April 3 was visible without difficulty to the naked eye. On April 23 the head was as bright as a third-magnitude star, and the tail 4° long. The greatest length of the tail was probably about 9°, but the comet was not a very conspicuous object on account of its slight elevation above the horizon before sunrise, and also on account of the moon-light. It is said to have remained visible to the naked eye from the early part of April to beyond the middle of May. Observations were continued in the southern hemisphere until about the end of July.

The determination of the orbit presented some difficulties, and the elements from early observations were not entirely accordant. Dr. S. Oppenheim's elements (Astron. Nachr., 2722), derived from observations extending to March 28, placed perihelion passage on April 5, 1886; the nearest point to the earth and greatest brilliancy (about four hundred and seventy-five times as bright as when discovered) were reached about May 1.

The spectrum was studied by Trépied, Perrotin, Rayet, Vogel, and others. The three bands common to comets and hydrocarbons were found—the central band, perhaps, somewhat intensified; and besides these bands there was also a continuous spectrum.

Dr. Müller, of Potsdam, has published in the Nachrichten (No. 2733)

a very interesting series of photometric observations of this comet and of the comet discovered by Barnard on December 3, 1885. The observations extended over the months of March and April, 1886; and both comets were increasing in brightness. Reducing the measures to a distance unity, the intrinsic brilliancy seems to have been tolerably constant; from which it may be concluded that the comets shone almost entirely with borrowed light. This conclusion is confirmed by Dr. Müller's spectroscopic observations, according to which the continuous spectrum predominates. Trépied, on the other hand, found that in Fabry's comet the proportion of reflected sunlight was small, gaseous elements predominating and the bands being much brighter than the continuous spectrum. Dr. Müller remarks that his observations show no effect of phase, and he suggests that this may be due to a variation in the inherent light of the comet as it approaches the sun and earth, or we may assume that the nucleus is made up of discrete particles by which the phase phenomena must to a great extent be modified.

Comet 1886 II:
=Comet *c* 1885.
=Barnard's comet.

A brief account of this comet was given last year, as it was discovered by Barnard on December 3, 1885, with a 6-inch Cooke equatorial. A small tail about 15′ long was detected by Tempel as early as December 31. In April and May the comet developed into quite a fine object with stellar nucleus and fan-shaped tail, 2° or 3° in length. It was seen with the naked eye on May 7 and 12 by Mr. Barnard, at Nashville, and on May 31 and June 3 by Mr. Tebbutt, at Windsor, New South Wales. The last observation published was made on July 19, at Cordoba. A careful series of "extinction observations" is given by Dr. Holetschek in the Nachrichten, No. 2739. The spectroscope showed the three ordinary cometary bands, with faint, continuous spectrum of the nucleus.

The latest elements computed by Thraen from observations between December 5, 1885, and May 10, 1886, place perihelion passage on May 3, and give a slightly hyperbolic orbit (eccentricity=1.0004). Whether the curve really differs from a parabola can not be decided until all the observations, including those from southern observatories, can be taken into account. Morrison has obtained hyperbolic elements agreeing tolerably well with those of Thraen. Earlier elements showed a slight resemblance to comet 1785 II, but it is not probable that the comets are identical.

Comet 1886 III:
=Comet *b* 1886.
=Comet 1886.... (Brooks 2).

This was discovered by Mr. W. R. Brooks, at Phelps, New York, on April 30, 1886, or in civil reckoning on the morning of May 1; his second comet within four days. Mr. Brooks described it as having a small but bright and star-like head, and a conspicuous tail. On May 4 there was a tail 10′ or 12′ long; very bright near the origin. Engelhardt, on May 6, found the tail 40′ long and nearly straight, while 8′ from the nucleus there was a faint secondary tail bending towards the south. Pechüle, observing from May 3 to May 12, detected two

nuclei or condensations in the head. Barnard says it was a most singular looking telescopic comet—"a perfect miniature of the naked-eye appearance of a great comet." It does not seem to have been observed beyond the last week of May, when its theoretical brightness was about half that at the time of discovery.

According to Wendell's elements the comet passed perihelion on May 5. Dr. Weiss called attention to the fact that at the ascending node the orbit approached quite near the orbit of the earth, so that when the earth passed the line of nodes, July 9, a meteoric shower visible in the southern hemisphere might result from particles following in the wake of the comet. We believe, however, that no unusual display was reported.

Comet 1886 IV:
= Comet *c* 1886.
= Comet 1886....(Brooks 3).

Discovered on the evening of May 22, 1886, by W. R. Brooks, in the constellation Virgo, a large, nearly round, and feebly luminous spot with a slight condensation occasionally visible. It was decreasing in brightness when detected, and passed out of sight early in July. Mr. Sherman, of the Yale Observatory, found the three cometary bands in its spectrum. Dr. S. Oppenheim has calculated an elliptic orbit with a period of about nine years. Dr. Hind makes the period very much shorter, not much more, in fact, than six and a quarter years, according to which the comet would return in the autumn of 1892. The perihelion passage took place on June 6 or 7. A new discussion of the orbit has been undertaken by Drs. Oppenheim and Bidschof, of Vienna.

Comet 1886 V:
= Comet *a* 1886.
= Comet 1886....(Brooks 1).

Discovered by Brooks on the evening of April 27, the first comet found in 1886. Until May 3 or 4 it was a round nebulous object 1′ or 2′ in diameter. An uncertain nucleus could occasionally be made out. On May 5 and 9 several bright points were seen in the nucleus, giving it a "granular" appearance. On May 18 the nucleus was of the eighth magnitude, and May 21 and 25, sixth to seventh magnitude with nearly circular coma 2′ 20″ in diameter. Dr. Krueger's elements show that the comet's nearest approach to the sun, 0.27 (the radius of the earth's orbit being unity), occurred on June 7.

Comet 1886 VI:
= Comet *d* 1886.
= Winnecke's comet.

Winnecke's periodic comet (five and two-thirds years) for which an ephemeris had been prepared by Dr. Lamp, was detected by Mr. Finlay, of the Cape of Good Hope Observatory, on August 19. During its two or three weeks of visibility it was a faint, misty object, 1′ or 2′ in diameter, without tail, but with some central condensation. Perihelion was passed on August 19, about twelve days earlier than predicted by Dr. A. Palisa. An attempt was made at Paris to photograph the comet, but without success.

Comet 1886 VII:
= Comet *e* 1886.
= Finlay's comet.

Discovered by Mr. W. H. Finlay, of the Cape of Good Hope Observatory, on September 26, 1886, and reported as "faint, circular, about 1′

in diameter, with some central condensation, and no tail." The possible identity with "De Vico's lost comet," 1844 I, (for which Brünnow found a period of 5.5 years), immediately attracted attention, and elliptic elements have been calculated by Boss, Krueger, Oppenheim, and Holetschek. The computation of the orbit presents some difficulties, and it is impossible to settle the question of identity until all observations at this return have received a thorough discussion—if it can be settled then. The last set of elements obtained by Professor Boss (Astron. Journ., v. 3, p. 43) place perihelion passage on November 22, 1886, and give an approximate period of 6.675 years. With this period the comet, if undisturbed, should return to the sun in July, 1893, under conditions quite favorable for observation. It is still visible, nearly five months after discovery.

Comet 1886 VIII:
= Comet *c* 1887.
= Barnard's comet.

A faint, telescopic comet was found by Barnard at Nashville on January 23, 1887 (the morning of January 24 in civil reckoning), which proved to have passed perihelion on November 25, 1886, and it therefore takes a place preceding the comet discovered by Barnard on October 4. As it was receding from the earth and the sun, it rapidly grew fainter. Perihelion distance obtained by Weiss was 1.4 times the mean distance of the earth from the sun.

Comet 1886 IX:
= Comet *f* 1886.
= Comet 1886 *f* (Barnard, October 4).
= Comet 1886.... (Barnard-Hartwig).

This comet was discovered by E. E. Barnard, at Nashville, Tenn., on October 4, 1886 (or morning of October 5). It was also discovered independently by Dr. E. Hartwig at the Bamberg Observatory on October 5, and by Dr. C. F. Pechüle, at Copenhagen, on October 6. It was an easy object in the telescope, and developed a tail early in October. By October 29 the nucleus was as bright as a star of the eighth magnitude, and the comet was visible to the naked eye as an ill-defined spot. Two distinct tails were detected about this time, and Barnard found a third on November 23. The comet was now easily seen with the naked eye, as conspicuous as a star of the fourth magnitude, with a slender train traceable for 7° or 8°. The tail seems to have reached a maximum length of about 10° during the first week of December, the theoretical brightness of the comet being then about twenty-five times that at discovery.

Riccò, of Palermo, found the spectrum composed of the three hydrocarbon bands, of which the middle one (green) was longest and brightest. The spectrum of the nucleus was continuous, but re-enforced at the bright bands.

Elements computed by Lieutenant Allen from observations reaching to December 10 show that perihelion was passed on December 16, 1886. No deviation from a parabola is indicated.

METEORS AND THE ZODIACAL LIGHT.

The Biela meteors of November 27, 1885.—Professor Newton has collected all the published data in regard to this great shower, and has submitted it to a thorough discussion in an article of nearly twenty pages of the American Journal of Science for June, 1886.

We quote merely his summary statement of conclusions:

"1. The maximum of the shower was near $6^h\ 15^m$ Greenwich mean time.

"2. Three hours after the maximum the number of meteors had diminished to one-tenth the maximum number, and it is not unreasonable to assume six hours as containing the principal part of the shower.

"3. The total hourly number of meteors visible at one place in a very clear sky to some one or other of a very large group of observers may at maximum be regarded as 75,000.

"4. In the densest part of the meteor stream, where and when the earth encountered it, the space that corresponded to each meteoroid was equal to a cube whose edge was about 20 English miles.

"5. The dense part of the stream was not over 100,000 miles in thickness.

"6. The *zenithal attraction* of the Biela meteors was about one-tenth of the observed zenith distance of the radiant.

"7. The radiant was an area several degrees across.

"8. It is reasonable to suppose that the meteoroids, while in the upper part of the atmosphere, before the paths become luminous, change direction by a glancing due to irregularity of form. After the resistance has developed heat enough to melt or burn off projecting angles of the stones, and the tracks become luminous, the forms of the bodies become rounded in front and the paths described are straight lines.

"9. The meteoroids encountered by the earth on the 27th of November, in 1872 and in 1885, did not leave the immediate neighborhood of the Biela comet earlier than 1841–'45, and may be treated as having at that time orbits osculating that of the comet. The determination of the paths of these meteoroids through their five and seven last revolutions about the sun seems to be a problem capable of complete solution."

Professor Newton's presidential address at the Buffalo meeting of the American Association, on "Meteorites, meteors, and shooting stars," has been published in Science (8 : 169–76), and in Nature (34 : 532–36).

M. P. F. Denza reports that a careful watch maintained on the night of November 27, 1886, at seven observatories on the Italian peninsula, showed no repetition of the great shower of 1885. This would indicate that the stream is of small extent but very dense, and would tend to strengthen the hypothesis that it originated in the recent disintegration of Biela's comet.

Herr Förster finds for the radiant points of the great meteor showers of 1872 and 1885:

1872	R. A. 23°.3	Decl. + 43°.3.
1885	23°.5 .	+ 43°.3.

A recent bulletin of the New England Meteorological Society gives a discussion, by Professor Newton, of a meteor seen on September 6, 1886, height, time and place of appearance and disappearance, etc. It is desired that observers should report the position of bright meteors, noting their paths among the stars, and trails, if any, with as much accuracy and detail as possible.

Mr. Denning publishes in the Monthly Notices for November some interesting results he has obtained from the study of a catalogue of more than 82,000 meteors from 3,035 radiants. Mr. Denning himself contributes to his catalogue no less than 7,000 meteors. He also, in another place, calls attention to the marked agreement between the orbit of Halley's comet and a pronounced meteor shower with radiant close to η Aquarii. The maximum shower occurs about May 6. This radiant needs further observation.

Relation of the zodiacal light to Jupiter.—Dr. Geelmuyden, speaking of Professor Searle's researches upon the zodiacal light, says: "If the zodiacal matter has the same position among meteoric matter in general as comets of short period among comets, it is to be expected that the fundamental plane of the zodiacal light will have some relation to Jupiter as the principal motor in deflecting the orbits, and therefore in collecting the matter. Now it is worth remarking that the most northerly point of Jupiter's orbit has the heliocentric longitude 188°, or with 60° east elongation 178° geocentric longitude; and for matter in the same plane, but nearer the sun, the approximation to coincidence with 160° is still greater."

THE SUN.

Motion of the solar system in space.—Several attempts have lately been made to obtain the direction and rate of motion of the solar system in space. These results are discordant among themselves, and, as the investigators have remarked, are not entitled to very great weight, on account of the meagerness of the data available, but it may not be without interest to give the values obtained.

Herr Homann, from a discussion of the spectroscopic observations made at Greenwich, and from the observations of Huggin and Seabroke, finds:

	Velocity of translation, in miles per second.	Apex of solar motion.	
		R. A.	Decl.
Greenwich	24.4 ± 2.7	320°.1	+41°.2
Huggins	30.1 ± 14.3	309 .5	+69 .7
Seabroke	15.2 ± 9.8	278 .8	+13 .6

There is only a rough sort of agreement, but all three unite in placing the apex considerably in advance, in right ascension, of the apex as found from the proper motions of stars by Struve, Airy, Dunkin, and others (the mean position generally assigned is, R. A. 260°; Decl. +35°), while Struve found a velocity of translation of only about 4½ miles per second.

Herr Homann is inclined to think that the velocity of translation of the sun does not differ very much from the velocity of the earth in its orbit, that is, 18½ miles per second. Dr. von Kövesligethy in 1883 found from spectroscopic observations that the rate of motion of the solar system was 8.6 geographical miles per second. The spectroscopic observations were insufficient to determine the direction, and he assumed the apex in R. A. 216°.0, Decl. +35°.1.

Dr. Ubaghs, of Liège, in making a preliminary examination of the aberration due to the motion of the solar system, pointed out by M. Folie, has obstained a result which would give a velocity of only about 180 feet per second.

The velocity of light and the solar parallax.—Professor Newcomb has published in vol. 2 of the "Astronomical papers prepared for the use of the American Ephemeris" the details of his researches on the velocity of light, made during the summer months of 1880, 1881, and 1882. The apparatus used, to which the name "photo-tachometer" has been given, is a modified form of Foucault's revolving mirror. The result obtained for the velocity of light *in vacuo* is 299,860 kilometers, or 186,327 miles per second, with a probable error of 30 kilometers. Michelson found in 1879 a velocity of 299,910 kilometers, and repeating his work at Cleveland in 1882, he obtained 299,853. Accepting the value 299,860 as the true one, it becomes of interest to consider the value thereby deducible for the parallax and distance of the sun. The latest and probably the most accurate determination of the constant of aberration is that of Dr. Nyrén, 20″.492. Combining this with the above velocity of light and Clarke's value of the earth's equatorial radius (6,378.2 kilometers), we obtain 8″.794 for the value of the solar parallax, almost exactly the same as that obtained from heliometer observations of Mars in 1877. The corresponding distance of the sun is 92,960,000 miles.

With regard to a possible difference between the velocities of rays of different colors, it is pointed out that the phenomena of variable stars seem to be conclusive against the hypothesis of any such difference. Were there a difference of one hour in the times of the blue and the red rays reaching us from Algol, this star would show a well-marked coloration in its phases of increase and decrease. No such effect, however, has been noticed. Recent researches by Professors Michelson and Morley have led to a similar result.

Transits of Venus 1874 *and* 1882.—The work of the United States Transit of Venus Commission is being rapidly carried to completion

under the immediate supervision of Prof. William Harkness. The reductions of observations made at the various stations for time, latitude and longitude are finished, the determination of longitudes having required a thorough examination of all the great chains of telegraphic longitude. A volume containing all of the observations for 1874—all of the 1874 work except the discussion of the photographs—is now in press.

Dr. Auwers reports, under date of January 11, 1886, that the reductions of the German heliometer measures are well advanced and that the printing has been begun; and M. Bouquet de la Grye announces for the French commission that the photographic plates, 1,019 in number, have been measured, and that the reductions are now half done, and will be finished about the end of 1887.

Theory of sun-spots.—Professor Young, in an article on "Recent advances in solar astronomy," makes the following comments upon an important paper by M. Belopolsky, of the Moscow Observatory, published in the Astronomische Nachrichten, No. 2722:

"Some recent investigations upon the rotation of fluid masses, by Jukowsky, of Moscow, as applied to solar conditions by his colleague Belopolsky, seem to warrant a hope that the phenomena of surface-drift in longitude, and even the periodicity of the spots, may soon find a rational explanation as necessary results of the slow contraction of a non-homogeneous and mainly gaseous globe. The subject is difficult and obscure; but if it can be proved, as seems likely, that on mechanical principles, the time of rotation of the central portions of such a whirling mass must be shorter than that of the exterior, then there will be of necessity an interchange of matter between the inside and outside of the sphere, a slow *surface*-drift from equator toward the poles, a more rapid *internal* current along and near the axis from the poles toward the equator, a continual 'boiling up' of internal matter on each side of the equator, and, finally, just such an eastward drift near the equator as is actually observed. Moreover, the form of the mass, and the intensity of the drift and consequent 'boiling-up' from underneath might and probably would be subject to great periodic variations.

"This theory falls in well with the facts established by Spoerer respecting the motion of the sun-spot zones, and the general though slow poleward movement of sun-spots."

Sun-spot observations at Kalocsa.—A summary (Astron. Nachr., 116: 31) of sun-spot observations at Kalocsa, 1880–1885, shows the predominance of spots in the southern hemisphere of the sun over those in the northern hemisphere, particularly well marked, since the beginning of 1883. A similar result is shown in the Greenwich observations, and has also been pointed out by Dr. Spoerer; on the other hand, from 1880 to 1883 the northern hemisphere had the greater number of spots. It has been noticed, furthermore, that since 1880 the spots show a tendency towards the equatorial zones.

Observation of sun-spot spectra.—Professor Young mentions a somewhat curious observation of sun-spot spectra, which he has recently made. He finds that under high dispersion the spectrum of the darkest part of the spot is not continuous, but is made up of countless fine, dark lines, for the most part touching or slightly overlapping, but leaving here and there unoccupied intervals which look like (and may be) bright lines. "It seems to indicate that the principal absorption which darkens the center of the sun spot is not such as would be caused by minute solid or liquid particles—by smoke or cloud, which would give a continuous spectrum; but it is a true gaseous absorption, producing a veritable dark-line spectrum, in which the lines are countless and contiguous."

Solar activity in 1886.—According to Professor Tacchini's observations (Comptes Rendus, 103: 120; 104: 216), it appears that there was a decided falling off in the number and size of sun-spots during the year 1886. In March, however, there was a considerable temporary increase; and on the 8th of May a magnificent group of spots was visible in the sun's northern latitude. A well-marked minimum occurred in November, and rather peculiar "secondary minima" seem to have fallen in the months of February, May, and August. Prominences also showed a diminution in number and size compared with those seen in 1885, but the fluctuations were much fewer than in the case of the spots. A particularly remarkable eruption was observed on March 9 and 10.

Professor Tacchini places the last great minimum of spots in March, 1879, and the last maximum in February, 1884; if then the decrease in the number of spots during the latter part of 1886 corresponds to a new minimum, we shall have an interval from the last maximum of only 2.8 years, whereas the mean interval is seven years. So short an interval between maximum and minimum is very exceptional, for the shortest known since 1750 is 4.3 years; the longest is ten years.

Total eclipse of the sun, August 28–29, 1886.—A party consisting of Lockyer, Tacchini, Schuster, Maunder, Perry, and others, was sent out by the British Government to the island of Grenada, in the West Indies, to observe the total eclipse of August 28–29, 1886. A full review of the results of the expedition can not be given until the detailed report is ready. Preliminary accounts show that only one division of the party, that with Mr. Lockyer at Green Island, failed entirely on account of clouds, though the observations at some of the other stations were more or less interfered with. Photometric observations and photographs of the corona and of its spectrum were obtained, and also good spectra of the prominences, showing the bright lines of highly incandescent vapors. In this respect the result resembles that obtained in the two previous eclipses, though it was thought possible that this year, being one when sun-spots were tending to a minimum, would be marked by the more continuous spectrum that bespeaks lower temperature.

Prof. W. H. Pickering, of Boston, observing from Fort Green, obtained a number of photographs and some interesting photometric observations. He also organized a series of observations of the shadow bands.

Observations of the partial phase were made at the Azores, Martinique, Port au Prince, and at several points along the eastern coast of the United States. No parties were sent out by the United States Government.

Photography of the solar corona.—Dr. Huggins's method of photographing the corona in full sunshine seems to have failed when submitted to a crucial test in the eclipse of last August. In a letter to Science, dated September 11, 1886, Dr. Huggins says: "The partial phases of this eclipse furnished conditions which would put the success of the method beyond doubt if the plates showed the corona cut off partially by the moon during its approach to and passage over the sun. As the telegrams received from Grenada, and a telegram I have received this day from Dr. Gill, at the Cape of Good Hope, state this partial cutting off of the corona by the moon is not shown upon the plates, I wish to be the first to make known this untoward result. I regret greatly that a method which seemed to promise so much new knowledge of the corona, which, under ordinary circumstances of observation, shows itself only during total eclipses, would seem to have failed. At the same time I am not able to offer any sufficient explanation of the early favorable results."

Mr. Common thinks it probable that this failure to get a picture of the moon projected on the corona was due entirely to the state of the sky; and Professor Langley, in a recent letter to Nature (35 : 53), adds his testimony as to the great effect of atmospheric diffusion upon the visibility of the corona. Moreover, Dr. Huggins says that he has not himself been able to obtain any satisfactory results since 1883, and that the plates taken by Mr. Ray Woods in 1884, in Switzerland, are inconclusive. The failure may be due to the abnormally large amount of air-glare from finely divided matter of some sort which has been present in the higher regions of the atmosphere since the autumn of 1883.

It is interesting to note that Professor Wright, of New Haven, in experimenting upon the visibility of the corona, succeeded in obtaining what he believed to be a coronal image upon a screen, when he, too, was brought to a standstill by these same "white skies" and "red sunsets." Professor Wright's method was to admit the sun's rays reflected from a heliostat, into a darkened room, and to cut out all but the blue and violet rays by a suitable absorbing cell, and then to form an image of the sun and its surroundings upon a sensitive fluorescent screen, stopping out the sun's disk itself.

Professor Young seems to have some slight hope of ultimate success of these efforts to reach the corona without an eclipse.

Langley's observations of hitherto unrecognized wave-lengths.—Professor Langley having traced the solar spectrum in the infra-red as far as wave-length =0.0027 of a millimeter, where it suddenly ceased, has since, with more delicate instruments, examined the emission spectra of various terrestrial substances at temperatures from that of fusing platinum to that of melting ice, and more particularly of temperatures corresponding to the ordinary conditions of the soil. The result has been to show that the maximum of heat from cold and black bodies has in every case a wave-length greater than 0.0027—greater, that is to say, than that of the lowest solar heat which reaches us. Professor Langley thus sums up (Am. J. Sc., 132 : 84–106) his investigation : "Broadly speaking, we have learned through the present measures with certainty of wave-lengths greater than 0.005 millimeter, and have grounds for estimating that we have recognized radiations whose wave-length exceeds 0.03 millimeter, so that while we have directly measured to nearly eight times the wave-length known to Newton, we have probable indication of wave-lengths far greater, and the gulf between the shortest vibration of sound and the longest known vibration of the æther is now in some measure bridged over."

The visual solar spectrum in 1884.—Professor Piazzi Smyth made a careful map of the solar spectrum in 1884 in order to determine whether any perceptible effect had been produced by the "white skies" so prevalent in that year. His observations have lately been published in a series of sixty plates, in the Transactions of the Royal Society of Edinburgh, vol. 32. He finds that the red and violet ends of the spectrum show a marked general dulling, such as should arise from the upper air being laden with minute opaque particles—whether from the Krakatoa explosion or any other source.

Thollon's map of the solar spectrum.—M. Thollon, in the Bulletin astronomique for July, gives some interesting details in regard to the great map of the spectrum for which the Lalande prize of the Paris Academy was awarded him about a year ago. An earlier map from A to H was finished by Thollon in 1879, but he determined to go over the work again with improved instruments, and to make a chart representing, with all the accuracy attainable, the positions, breadths, and relative intensities of the lines, a chart which will enable us to determine in the future whether any changes have taken place. For even now, from the comparison of M. Thollon's chart with that of Ångström, there is a strong suspicion that some change has occurred in the intensity of several lines between B and C.

M. Thollon has carried the map from A to *b*, and it is to be continued to the violet by M. Trépied. It is now more than 33 feet long (though it covers little more than one-third of the spectrum), and contains about 3,200 lines, nearly 900 of which are distinguished as of telluric origin. The instrument employed was a large spectroscope with bi-

sulphide of carbon prism, kept at an even temperature by running water. The measures were made with a fine glass pointer.

Cornu's device for distinguishing the telluric lines in the solar spectrum.—At the meeting of the Royal Astronomical Society, on June 11, 1886, M. Cornu gave a description of an ingenious method he has devised for distinguishing between those lines of the solar spectrum which are atmospheric and those which are due to solar absorption. The east and west equatorial limbs of the sun are alternately thrown on the slit of the spectroscope by means of an oscillating mirror. As one limb of the sun is approaching us and the other receding, there is a real difference of wave-length in the same radiation as obtained from the two limbs, and consequently the solar lines appear to oscillate while the atmospheric lines remain perfectly stationary. "It is as if you shook the spectrum; and if a line were a solar one it moved, if a terrestrial one it remained steady."

The absorption spectrum of oxygen.—About three years ago M. Egoroff was able to show that the great groups A and B in the solar spectrum were due to the absorption of oxygen. More recently the *a* band was also found to be due to the same gas. M. Janssen, studying the absorption of oxygen, has now discovered that, under certain conditions, the gas yields another spectrum, composed no longer of lines easily separated, but of shaded bands, which can only be resolved with great difficulty. This system of bands appears for moderate pressures much later than the spectrum of lines, but it shows itself very quickly with increase of the density; the two systems are so different that it is possible to obtain either the first without the second, or *vice versa*. M. Janssen was at first unable to explain how it was that these bands were not visible in the solar spectrum when they were easily obtained by passing light through thicknesses of oxygen far less than the sun's light has to traverse before reaching us. But further experiments showed that these bands did not develop in proportion to the thickness of the stratum of oxygen producing them, multiplied by its density, but in proportion to the thickness multiplied by the square of the density. The density of our atmosphere being small as compared with some of the pressures at which M. Janssen worked, the non-appearance of these bands amongst the telluric lines of the solar spectrum is readily explained.

M. Janssen is continuing his experiments at Meudon, and is building tubes which can be loaded with 1,000 atmospheres of hydrogen, oxygen, or carbonic acid. In this last case the real density of the gas will be superior to the density of water. (Nature.)

For a thorough and authoritative review of recent advances in our knowledge of the sun the reader should consult Professor Young's article which appeared in the Popular Science Monthly for November, 1886 (30:24–33), and also his "Ten Years' Progress in Astronomy," in vol. 5 of the Transactions of the New York Academy of Sciences.

THE PLANETS.

MERCURY: *The mass of Mercury.*—Dr. Backlund has published in the Bulletin astronomique for October a new mass of Mercury, obtained incidentally in his discussion of the motion of Encke's comet. The new result in question is $\frac{1}{2668700}$, the sun's mass being unity, and this is the largest value of the mass of the planet yet obtained. Dr. Backlund states that, even supposing the acceleration of the comet's mean motion to have been constant during the entire period, 1871–'85, it is not possible to represent satisfactorily the five apparitions of the comet during that period on the assumption of a mass of Mercury less than $\frac{1}{5000000}$.

VENUS: *Semi diameter of Venus.*—Mr. Thackeray, discussing the observations of Venus made at Greenwich from 1866 to 1884, finds that the amount of personality in the measures is much greater than the correction due to the instrument, and that, though a greater number of observers by compensating one another might give increased accuracy to the value of the semi-diameter, it is just as likely that they should not.

THE EARTH: *Geodetic Congress.*—We learn from Nature that the International Geodetic Conference met at Berlin in October, 1886, to settle the organization of the central geodetic bureau (which is to have its permanent seat at Berlin), and to determine upon the best method of executing the resolutions passed at Rome and Washington in 1883 and 1884, respecting the actual measurement of a degree on the earth's surface. The adoption of Greenwich as a first meridian is to be strictly enforced, but the introduction of international normal time is postponed on account of insuperable practical difficulties.

The proposed change in the beginning of the astronomical day.—It is to be regretted that no agreement has yet been reached by astronomers upon the proposition to change the beginning of the astronomical day from noon to midnight.

The general sentiment is opposed to making any change until it is clear that it will be adopted by a majority of astronomers, and until the proper modifications have been introduced into our principal ephemerides. The new day has been provisionally adopted by Mr. Christie, at Greenwich, and the board of visitors have recommended that it be introduced into the Nautical Almanac for 1891. On the other hand, the superintendents of the German and American ephemerides oppose any change; and there seems to be great danger that the agitation of the question by the Washington Meridian Conference in 1884 may introduce new confusion rather than remove the old. At present there is little prospect of the plan meeting with anything like a general acceptance before the beginning of the next century.

Theory of the moon's motion.—Several valuable papers upon the lunar theory have been published by Hill and others. Reference should be made to the papers themselves, cited in our Bibliography.

Mr. Hill has received the gold medal of the Royal Astronomical Society for his laborious and masterly researches upon this difficult subject.

An interesting historical note on the inequalities of the motion of the moon which depends on the figure of the earth, is given by Professor Hall in the Annals of Mathematics, vol. 2, No. 5.

MARS: *The "canals" of Mars.*—M. Perrotin and his colleagues at Nice succeeded in recovering many of Schiaparelli's enigmatical "canals" at the last opposition of Mars, although the planet was seen under very unfavorable conditions. Its apparent diameter at this opposition was only 14″, against 25″ at the opposition of 1877, when the canals were discovered. The canals were made out by several observers at Nice, and were recognized as having the same general outline and position attributed to them by Schiaparelli in 1882. They seem, therefore, to be essentially permanent, forming a sort of network of grayish lines projected against the brighter equatorial regions of the planet. Compared with the thickness of the spider lines of the micrometer, the finest of these lines appear to have a width which corresponds to an arc of 2° or 3° on the surface of Mars. Some of them measure from 50° to 60° in length, and several are double, composed of lines strictly parallel, separated, according to Schiaparelli's estimate, by intervals of from 6° to 12°. All of this speaks well for the purity of the atmosphere at Nice, the excellence of the 15-inch Henry refractor, and the keenness of the observers.

During the study of the planet (from the end of March to the middle of June) some change seemed to be taking place near Kaiser Sea. On May 21 this region, from 10° to 55° north latitude, was hidden by a luminous veil somewhat softer in color than the continents, very much as if clouds in regular parallel bands were stretched across the planet from northeast to southwest. At moments these clouds became transparent, exposing the outline of the prolongation of Kaiser Sea. Other similar cloud phenomena were observed on subsequent days. M. Perrotin suggests that these phenomena were really produced by clouds or mists circulating in the atmosphere of Mars, and concludes that they are, in such case, the act of an element belonging to the atmosphere, or to the surface of the planet, susceptible of motion and modification in a comparatively short time.

Mr. Denning, who has been an attentive observer of Mars, has not been able to make out the canals in the detail assigned to them by Schiaparelli, although he has distinguished a large number of appearances highly suggestive of these configurations. Mr. Denning concludes a review of his recent observations of the planet (Nature, 34: 105) as follows:

"Many of our leading treatises on astronomy attribute a dense atmosphere to Mars, but nothing has been observed during my recent observations to corroborate this theory. It seems to me far more plausible

to assume that the atmosphere of this planet is extremely attenuated. The chief spots are invariably visible, and the phenomena occasionally observed are rather to be imputed to the vagaries of our own atmosphere than to that of Mars.

"Jupiter and Saturn are doubtless enveloped in dense vapors shrouding their real surfaces from terrestrial eyes. Their markings are atmospheric, though in some cases very durable, and constantly undergoing changes of aspect and displacements of position by longitudinal currents. On Mars a totally different nature of things prevails. Here the appearances described are absolute surface markings displaying none of the variations which are so conspicuously displayed on Jupiter. - - - It seems to me that the very pronounced character of the markings and their great permanency are quite opposed to the idea that the planet is surrounded by a dense cloud-laden atmosphere."

Dr. Lohse has used, in observing Mars, a double-refracting prism, achromatized for the extraordinary ray; this prism, placed before the ocular of the telescope, brings out more sharply the details of the planet's surface by reducing the polarized light reflected from its atmosphere.

Satellites of Mars.—Professor Hall was able to observe the outer satellite, Deimos, on four evenings in March, 1886, but the inner satellite was seen only once, and was then so faint that no measurements could be made. Both little bodies were near their predicted places.

THE MINOR PLANETS.—Eleven minor planets were added to the list in 1886, the last one bearing the number 264; the brightest was of the eleventh magnitude. Seven of the new-comers belong to Dr. Palisa, making the total number discovered by him fifty-seven. Dr. Peters has now discovered forty-six and Dr. Luther twenty-three.

The dates of discovery and the names, as far as assigned, are given in the following table:

Minor planets discovered in 1886.

No.	Names.	Date of discovery.	Magnitude at discovery.	Discoverer.	Observatory.
254	Augusta	March 31, 1886.	13.5	J. Palisa	Vienna.
255	Oppavia	....do	13.5	....do	Do.
256	Walpurga	April 3	12.5	....do	Do.
257	Silesia	April 5	13	....do	Do.
258	Tyche	May 4	11.3	R. Luther	Düsseldorf.
259	Aletheia	June 28	12	C. H. F. Peters	Clinton.
260	Huberta	October 3	13.5	J. Palisa	Vienna.
261	Prymno	October 31	11.2	C. H. F. Peters	Clinton.
262	Valda	November 3	12	J. Palisa	Vienna.
263	Dresda	....do	12	....do	Do.
264	Libussa	December 22	11.5	C. H. F. Peters	Clinton.

Number 253, discovered by Dr. Palisa on November 15, 1885, has been named *Mathilde.*

The influence of phase on the brightness of the minor planets.—Dr. G. Müller, of the Potsdam Observatory, is led to believe from observations of seven asteroids with a Zöllner photometer, that there is a real connection between the phase of these bodies and their apparent brightness, and that Lambert's law of phase brightness does not apply to them. The planets are separated into two classes. In the first class, class, which embraces Vesta, Iris, Massilia, and Amphitrite, the changes in brightness are only perceptible as the planet approaches opposition, thus resembling Mars in their behavior; in the second, which contains Ceres, Pallas, and Irene, the changes in brightness seem to be coextensive with the changes of phase, giving a light curve, like that of the the moon or Mercury.

The asteroid ring—M. A. Svedstrup gives in the Nachrichten, Nos. 2740–41, an interesting abstract of a recent investigation, for which he received the gold medal of the Royal Danish Academy—a statistical examination of the orbits of 198 of the small planets, considered as part of a cosmical ring around the sun. The orbit obtained for the "mean planet" shows an inclination of about 6° and a mean distance of 2.64. The mass of this fictitious planet corresponds to an apparent magnitude, at opposition, of 6.7.*

Relation of the asteroid orbits to that of Jupiter.—Professor Newton points out the interesting fact that the plane of Jupiter's orbit coincides almost exactly with the mean plane of the orbits found for the first 251 asteroids, understanding by the mean plane, the plane whose pole is the center of gravity of the poles of the asteroid planes; the difference between the poles is, indeed, only 30′.

JUPITER: *The "red spot."*—The "great red spot," some 30,000 miles in length by 8,300 in width, has now been the principal object of interest on the planet for eight years. It was faint during the last season, but far more conspicuous than in 1885. Professor Young obtained, from eight observations made between March 17 and June 29, 1886, a rotation-time of the spot of $9^h\ 55^m\ 40^s.7 \pm 0^s.2$, showing that the remarkable retardation of the period still persists. This is brought out by the following figures:

In 1879	Mr. Pratt made the period....	$9^h\ 55^m\ 34^s.9$
1880–'81	Mr. Hough made the period...	37 .2
1882–'83	Mr. Hough made the period...	38 .4
1883–'84	Mr. Hough made the period...	38 .5
1884–'85	Mr. Hough made the period...	40 .1
1886	Mr. Young made the period...	40 .7

Professor Young, on re-reducing Mr. Pratt's observations of 1879, obtains $9^h\ 55^m\ 34^s.05$, and he finds from a series of observations made by Prof. C. W. Pritchett, in 1882, $9^h\ 55^m\ 38^s.15$. A small round white spot

*In the Bull. astron., 3: 415, this is corrected to 6.0 magnitude.

observed at Princeton in March and April, 1885, gave a period of 9 55^m $11^s.14$. "It is noteworthy that although this spot was in a higher latitude (about 50° south) than the red spot, it yet rotates more rapidly." Professor Young remarked the apparent overlapping of the southern belt and the red spot which took place towards the end of March and the beginning of April, and which was seen by many English observers (Observatory, May, 1886, vol. 9: p. 188); but whilst admitting that it was impossible to say which was uppermost, he was inclined, in opposition to Mr. Denning's view, to believe the red spot to be the lower. Mr. Denning has pointed out that the apparent partial coalescence of the two markings was simply due to an arm of the southern belt overtaking the red spot, the former having a rotation period shorter by about 19^s than the latter.

Mr. Denning finds evidence of regular recurrence in many of the prominent markings on this planet.

SATURN: *The satellites of Saturn.*—Professor Hall has finished a very important discussion of the six inner satellites of Saturn, and his work has been published as Appendix I to the Washington Observations for 1883. The observations of Professor Newcomb in 1874, and Professor Hall's own observations from 1875 to 1884, are given in detail; these are followed by the formation of equations of condition and their solution, and the work concludes with useful tables of the satellites' motions.

A remarkable result of the discussion is that the Washington observations of the five inner satellites can be satisfied within the limits of their probable errors by circular orbits. It was hoped that the observations would determine the positions of the lines of apsides with such accuracy that the motions of these lines would be known, and that thus we might obtain data for a new determination of the mass of the ring and of the figure of the plant. But the resulting circular orbits for the inner satellites make the position of a line of apsides indeterminate, and for the present the mass of the ring remains unknown.

The mass of Saturn has been computed from the elements found for Titan, Rhea, Dione, and Tethys with the separate results for the reciprocal of the mass, —

From Titan	3480.07 ± 1.138
Rhea	3450.43 ± 6.202
Dione	3463.68 ± 8.379
Tethys	3463.41 ± 10.629

or, the mean result from the four satellites, is

$$\text{Mass of Saturn} = \frac{1}{3478.7 \pm 1.10}$$

the mass of the sun being unity.

In a paper in the Astronomische Nachrichten (No. 2743) entitled "Comparison of the five inner satellites of Saturn made at Toulouse in

1876 and 1877," Professor Hall discusses the old method of observing these difficult objects by noting their conjunctions with the ends of the ring, or with some other marked feature of the Saturnian system, but concludes that the filar micrometer measures are at present among the best we have. He is inclined to think that the heliometer, if it can be made large enough, must be one of the best instruments for dealing with measurements of such objects as Saturn and Jupiter. This suggestion is being carried out by Mr. Asaph Hall, jr., in a series of observations of Titan with the 6-inch heliometer of the Yale College Observatory.

The following table represents the results of Professor Hall's investigations upon these satellites. The elements of Titan, however, and the values of the node and inclination of the ring are adopted from Bessel. Mimas, Enceladus, Tethys, Dione, and Rhea are assumed to move in the plane of the ring, and Hyperion in the plane of Titan.

Elements of the satellites of Saturn, 1880.

Satellite.	Mean daily motion.	Time of revolution.	Mean distance from Saturn.
	°	d	″
Mimas	381. 99078572	0. 9424311	26. 80
Enceladus	262. 73177276	1. 37021875	34. 40
Tethys	190. 69838434	1. 88779785	42. 734
			″
Dione	131. 53500629	2. 7369140	54. 734 ±0. 0442
Rhea	79. 69010973	4. 5174991	76. 537 ±0. 0459
Titan	22. 57700000	15. 9454245	176. 915 ±0. 0193
Hyperion	16. 919883	21. 276742	213. 98
Iapetus	4. 53794773	79. 3310152	515. 5195 ±0. 02645

Satellite.	Longitude of Peri-Saturnium.	Eccentricity.	Inclination to ecliptic.	Longitude of node.
			° ′ ″	° ′ ″
Mimas	Circular	Zero	28 10 16. 7	167 55 5. 9
Enceladus	do	do	28 10 16. 7	167 55 5. 9
Tethys	do	do	28 10 16. 7	167 55 5. 9
Dione	do	do	28 10 16. 7	167 55 5. 9
Rhea	do	do	28 10 16. 7	167 55 5. 9
	° ′ ″			
Titan	268 37 56. 0	0. 02841836	27 33 56. 7	168 10 34. 8
Hyperion	83 37 55. 2	0. 1	27 33 56. 7	168 10 34. 8
Iapetus	353 14 56. 5	0. 027795	18 33 39. 5	142 26 41. 4

The motion of Hyperion.—Tisserand in investigating the case of two satellites moving around their primary in orbits but little inclined to each other has shown that if the mean motions are very nearly commensurable, and if the motion of one was originally circular and uniform, the perturbations caused by the other would have for their principal effect to transform this motion into motion in a Keplerian ellipse with a uniform rotation of the major axis. Applying this to the case of Hyperion perturbed by Titan, which has been investigated by Hall and Newcomb, and in which there is one of the nearest approaches to commensurability of mean motions to be found in the solar system, M.

Tisserand finds that his results agree closely with the facts of observation, the computed rate of retrograde motion of the perisaturnium of Hyperion being 18°.8 per annum, whilst the observed quantity is 20°, and he also finds that his value of the mass of Titan ($\frac{1}{10750}$) differs little from that obtained by Newcomb. (Observatory, November, 1886, 9:360.)

URANUS.—Observations of the planet made by Dr. H. C. Wilson at the Cincinnati Observatory in 1883 (recently published in Astron. Nachr., 2730), seem to confirm Professor Young's observations (Astron. Nachr., 2545), that the equator of the planet does not coincide with the plane of the satellites' orbits.

NEPTUNE: *Satellite of Neptune.*—Marth calls attention (Month. Not., 46:507) to what appears to be a remarkable change in the position of the plane of the orbit of Neptune's satellite. He noticed that the orbit from the Malta observations of 1863–'64 did not agree with that from the observations of 1852. The node and inclination obtained by Newcomb in 1874 showed a movement in the same direction, and the motion of these elements is still further confirmed by the orbit recently published by Professor Hall from his own observations at Washington. The probable errors are so small that it seems hardly plausible or possible to attribute the change to systematic errors of observations. Mr. Marth calls for careful observations to strengthen the evidence.

REPORTS OF OBSERVATORIES.

The following account of the recent activity of astronomical observatories is compiled from all available sources, the "Vierteljahrsschrift" furnishing, as usual, the data for most of the observatories, although the latest reports there published are for the year 1885. I am indebted to the directors of many observatories for the direct communication of information in regard to the institutions under their control.

An alphabetical list of astronomical observatories, compiled by Mr. Boehmer, will be found in the Smithsonian Report for 1885.

M. Lancaster, of the Bruxelles Observatory, has published a useful directory of observatories and astronomers.

Algiers Observatory (1886).—The French Government has granted the funds necessary for the completion of the observatory, and two assistants have been sent to join M. Trépied. A time service has been organized for the cities of Algiers and Tunis, and the observatory will cooperate in geodetic work with field parties. Stellar photography will receive special attention. The observatory possesses a spectroscope by Thollon giving a spectrum 10 meters in length.

Allegheny Observatory (1886).—The work during 1886 has consisted of an extension of former researches on invisible radiations, and on the absorption and radiation of heat by the earth's atmosphere, and also of researches upon the absolute temperature of the lunar surface. In con-

nection with this latter investigation a new field of exploration has been opened in spectral regions, where the planet's own radiations towards space, of very great wave-lengths—exceeding one one-hundredth of a millimeter—are now for the first time found.

Professor Langley, in giving a portion of his time to the Smithsonian Institution, has not resigned the active directorship of the observatory, and all communications relative to the scientific or business affairs of that institution should be addressed to him at Allegheny as usual. Mr. F. W. Very continues at the observatory as senior assistant. Mr. Keeler is now at the Lick Observatory, and has been succeeded at Allegheny by Mr. James Page, jr.

Amherst (1885).—This observatory, named in honor of the Hon. Abbot Lawrence, was built in 1847, and has been employed chiefly for purposes of instruction. Professor Todd was appointed director in July, 1881, and his report covers the years 1881–1885, inclusive. The instruments of the observatory are: A 7¼ inch Clark equatorial, a 3-inch Gambey transit circle, and a 6⅔-inch Pistor & Martins transit instrument, with mean-time and sidereal clocks, chronograph, and subsidiary apparatus. The equatorial is provided with two small cameras for celestial photography. Observations are made of sun-spots, of the phenomena of Jupiter's satellites, occultations of stars by the moon, etc. The provisionally adopted position of the observatory is: Latitude, $+42^\circ\ 22'\ 17''.1$; longitude, $4^h\ 50^m\ 4^s.67$ west of Greenwich.

Ann Arbor (1886).—The observatory is known as the Detroit Observatory, having been founded through the liberality of citizens of Detroit. Valuable additions and improvements have been made by means of further contributions from the same source and from the city of Ann Arbor, and also by appropriations made by the board of regents of the University of Michigan, to which the observatory is attached. The building consists of a main part, with a movable dome, and two wings. The east wing contains the large meridian circle by Pistor & Martins and a sidereal clock by Tiede, of Berlin. The west wing contains the library of the observatory, a chronograph with Bond's new isodynamic escapement, and the smaller instruments. This wing connects with the residence of the director. In the dome is mounted a large refracting telescope, with an object-glass 13 inches in diameter, constructed by the late Henry Fitz, of New York.

Much attention is given to instruction in astronomy, and through the liberality of the legislature a small observatory for the purpose of instruction has been erected on the observatory grounds near the main building. It contains an equatorial telescope of 6 inches aperture and a transit instrument of 3 inches aperture, with zenith telescope attachment. A building near by contains computing rooms and rooms for observers, and a workshop where necessary repairs and attachments for the instruments can be made. A set of self-registering meteorologi-

cal instruments has recently been added. It consists of Hough's barograph and thermograph and an anemograph.

The observatory is under the direction of Prof. M. W. Harrington, who is assisted by Mr. J. M. Schaeberle and a meteorological observer. Professor Harrington has devoted considerable time during the past few years to photometric observations, especially of the asteroids. Mr. Schaeberle has made observations with the meridian circle.

The observatory plant is valued at about $40,000, and the annual expenditures amount to about $3,000. It should be mentioned that the American Meteorological Journal is edited here by Professor Harrington.

Armagh (1886).—Under the direction of Dr. Dreyer the Armagh catalogue of 3,300 stars has been published.

Bamberg (1886).—This observatory, founded by the will of the late Dr. Remeis, of Bamberg, who died in 1882, will be provided with a 7-inch heliometer, the largest instrument of its kind made. Dr. Hartwig proposes to take up the systematic investigation of stellar parallax, and the investigation of the physical libration of the moon.

Berlin (1885).—With the meridian circle, Dr. Küstner has observed a series of comparison stars for planets and comets, stars which have been occulted by the moon, stars for heliometer investigations, etc. There have been made in all 2,096 observations of right ascension and 1,936 of declination; the reductions are up to date. A new observing list, containing the Pulkowa "Zusatzsterne" and Argelander's proper motion stars—about 1,000 objects in all—was started in 1886. The transit has been used for observations of circumpolars, and also for continuing the observations upon seven selected pairs of stars, which are to furnish data for determining the constant of aberration. With the 9-inch refractor Dr. Knorre has observed a large number of comets and planets, and with the aid of his "declinograph" he has determined the positions of about a thousand stars, some as faint as the thirteenth magnitude. Dr. Battermann observed occultations with the 4.6-inch refractor. The investigations upon the movements of piers have given interesting results, and the clock which has been for four years in a hermetically sealed case, continues to perform most satisfactorily.

Bonn (1885).—The meridian circle was devoted, mainly, to continuing the Gesellschaft zone observations. Volume VIII, the Southern Durchmusterung, was published during 1886, and the printing of the twenty-four charts which are to accompany this work has been begun. The reduction of the zone work is not quite finished. The director, Dr. Schönfeld, has been assisted in observing by Drs. Scheiner, Deichmüller, and W. Luther. Dr. Scheiner was absent a considerable portion of the year, serving a term of military duty.

Breslau (1885).—The observatory, under the charge of the veteran Dr. Galle, is engaged in meteorological and magnetic work. Assistant, Dr. Lachmann.

Buchtel College Observatory (1886).—Professor Howe has devoted his time to instruction in practical astronomy. The cost of the observatory was about $5,000.

Bucknell University Observatory.—Mr. William Bucknell has given the sum of $10,000 for an observatory at Lewisburgh, Pa. A 10-inch equatorial has been ordered from Clark and a 3-inch transit from Ertel. The building is of brick, 25 feet by 150 feet, a dome 16½ feet in diameter surmounting the central tower.

The observatory, under the direction of Prof. W. C. Bartol, is to be used for instruction in practical astronomy, and will be ready in June, 1887.

Chabot Observatory (1886).—This new observatory, the gift of Anthony Chabot, esq., to the city of Oakland, Cal., is under the direction of Mr. F. M. Campbell. The instruments are, an 8-inch equatorial, with micrometer and spectroscope, a 4½-inch transit, chronograph, clocks, etc. The geographical position given (Sid. Mess., 5:286) is: Latitude, $+37° 48' 5''$; longitude, $3^{h} 0^{m} 54^{s}.3$ west of Washington.

Cincinnati (1886).—The Cincinnati Observatory was founded in 1842 by an astronomical society, and was afterward transferred to the University of Cincinnati, of which it now forms one of the departments. A new building was erected in 1870 upon Mount Lookout, about 4 miles east and 2 miles north of the central portion of the city. The observatory grounds comprise 4 acres on the summit of the hill. The building is of brick; it consists of a central portion supporting the dome, and two wings, the western being furnished with meridian shutters, and the eastern containing the library.

The observatory possesses the Mitchel refractor of 11 inches aperture, made by Merz & Mahler, and supplied with a filar micrometer and a double-ring micrometer. The magnifying powers range from 90 to 1,500. There is also a portable equatorial of 4 inches aperture by Clark, with magnifying powers ranging from 15 to 250. The transit instrument, by Buff & Berger, has an aperture of 3 inches and is furnished with a latitude level and an eye-piece micrometer for measuring differences of declination. The total value of the instruments is estimated to be about $12,000. The library contains over fifteen hundred bound volumes besides a large number of pamphlets.

The financial support is derived from a city tax, the yearly income from which is about $5,000. This provides for the salary of the director, one assistant, and a janitor, the payment of the ordinary expenses, and the publication of results. The purpose of the observatory is both educational and scientific. Instruction in astronomy is given in connection with the university, and the observatory is also open to the public for the first hour of each evening.

The principal work of the past year (1886) has been the prosecution of the zone observations with the 3-inch transit instrument. In these zones about 4,000 stars between the declinations $-19°$ and $-22°$ have

been observed, most of them three times or more. The work of preparing this catalogue for publication is already commenced, and in the progress of the work Professor Porter has detected a number of interesting cases of proper motion. The catalogue will probably be issued during the coming year. A few observations of nebulæ, double stars, and comets were also made during the early part of the year, but were suspended owirg to the resignation of Mr. H. C. Wilson, assistant astronomer.

The work proposed for 1887 is the completion of the observations required for the zone catalogue, and after that the continuation of a series of charts of southern nebulæ.

Cointe (1886).—The new observatory attached to the University of Liège, Belgium, is under the direction of M. Folie, the director of the Brussels Observatory. The instruments are a 10-inch equatorial and 6-inch meridian circle (diameter of circle about 31.5 inches), both by Cooke, with numerous smaller astronomical and geodetic instruments, and a set of magnetical and meteorological instruments. M. Folie is assisted by Dr. L. de Ball and M. P. Ubaghs.

Columbia College Observatory (1886).—The observatory is upon the top of the college library building, 100 feet above the level of Forty-ninth street, New York City. The 13-inch Rutherford equatorial, 3-inch transit, and zenith telescope are mounted in a room about 24 by 30 feet. The instruments rest upon solid piers of masonry, which are supported by heavy iron girders, the floors and ceilings nowhere touching the girders. The instrumental equipment embraces also a 5-inch equatorial (not mounted at present), a Troughton & Simms transit, spectroscope and subsidiary apparatus, clock, chronometers, portable transit, personal-equation machine, etc. The dome is by Waters & Son, of Troy, New York, and consists of a paper covering with wooden ribs. The shutters of the transit slits are also paper, and open by the action of springs.

Some trouble is caused by vibrations from the railroad trains (over one hundred a day) constantly passing within 100 feet of the building, but at times the instruments are very steady.

A careful redetermination of the geographical position of the observatory will be made, as the old longitude seems to be somewhat in error. It is also hoped to devote the Rutherford equatorial, which is supplied with a photographic corrector, to astronomical photography.

Professor Rees, the director, has but one assistant, and the greater part of his time is required to carry on a very complete course of instruction in practical astronomy, designed especially for training engineering students.

Dearborn Observatory (1886).—The Dearborn Observatory is the property of the Chicago Astronomical Society, but is upon ground leased to it by the now extinct University of Chicago, and may at any time be required to vacate. A new site has not yet been selected. Observa-

tions of Jupiter and of double stars have been made with the equatorial during 1886, and the necessary observations for furnishing time to the city of Chicago have been made with the meridian circle. A catalogue of two hundred and nine new double stars has been sent to the Nachrichten. It is expected that observations of double stars, Jupiter, and the satellites of Uranus will be kept up during the coming year. The instruments of the observatory are valued at $30,000. There is no permanent endowment, and Professor Hough carries on his work without assistants.

Deutz (1885).—Herr Emil Mengering established in 1884 a private observatory, the principal instrument being a 5-inch refractor by Reinfelder & Hertel. Physical observations of the moon and Jupiter have been made, and attention is being directed to astronomical photography and spectroscopy. Approximate geographical position: Latitude, $+50° 56' 33''$; longitude, $+0^h 25^m 45^s.0$ west of Berlin.

Dresden (1885).—At Baron von Engelhardt's observatory observations were made of comets, nebulæ, double stars, the phenomena of Jupiter's satellites, occultations by the moon, etc.

Dresden (1885)—Dr. Drechsler, of the "Mathematischer Salon," continues a series of meteorological observations begun in 1828.

Düsseldorf (1885).—Since 1847, 1,271 observations of 157 asteroids have been made.

Frankfort-on-the-Main (1885).—Herr Epstein continues his star-gauges and his observations of sun-spots.

Geneva (1885).—Four hundred and ninety-eight chronometers were tested during 1885, some of them showing an uncommon degree of excellence. Forty-two chronometers were entered on December 1, 1885, for a twelve-weeks' special trial of temperature compensation. M. Kammermann has employed the 10-inch equatorial in observations of comets, nebulæ, and satellites. Meteorological observations are continued as in former years.

Gotha (1885).—Dr. Becker has given up the greater part of his time to the reduction of his zone observations. The equatorial which has received a new 4½-inch objective by Reinfelder & Hertel, and has been thoroughly repaired, was remounted in October. A series of observations was made with the meridian instrument.

Greenwich (1886).—The annual report of the astronomer royal, Mr. Christie, was submitted to the board of visitors of the Greenwich Observatory on June 5, and gives an account of the progress and activity of the observatory for the year ending May 20, 1886. The regular work of the transit circle and the altazimuth has been continued, and very satisfactory results have been obtained with the apparatus for determining absolute personal equations brought into use with the former instrument some months ago. Spectroscopic observations include a considerable number made of the new star which burst out in the great nebula of Andromeda. The spectroscopic observations of Sirius indi-

cate, as in the last three years, a displacement of the F line towards the blue; this displacement would correspond to a motion of the earth towards Sirius at a rate of something more than 20 miles per second, though, from the nature of the observations, the amount of such a motion can not be considered as very accurately determined. For the year 1885 a photographic record of the sun's surface can be made out for three hundred and sixty days by filling up the gaps in the series of Greenwich photographs from photographs obtained in India and the Mauritius. Observations of comets and of casual phenomena have been made with the equatorials; and the magnetic and meteorological observations, the time-service, etc., have been kept up as in previous years. The full import of the statement that the reductions of the observations are keeping pace with their registration will be appreciated by all who are engaged in routine astronomical work.

In regard to the new equatorial Mr. Christie says: "The construction of an object-glass of 28 inches aperture and 28 feet focal length, with suitable tube, to be mounted on the southeast equatorial, has been authorized by the Government, and the necessary funds have been provided in the estimates. The work has been intrusted to Mr. Grubb, with whom I have arranged the details of the tube, which is to be of special construction, adapted to the conditions of the mounting, and available for spectroscopy and photography as well as for eye observations. Mr. Grubb proposes to provide means for readily separating the lenses of the object glass to such a distance as will give the proper correction for photographic rays."

It is proposed to refit the 12¾-inch refractor for astronomical photography by placing a combination of a convex flint and a concave crown lens about 2 feet within the focus, in order to correct the chromatic aberration of the objective for the photographic rays without alteration of the focal length.

Grignon (1885).—Observations of sun-spots and of the physical appearance of planets, etc.

Hamburg (1885).—Only one hundred and nineteen nights in the year were favorable for observing. Besides the meridian observations and the observations of planets and comets, a large number of chronometers have been tested. Dr. Schrader has left the observatory to take part in a scientific exploring expedition, and his place is filled temporarily by Dr. Wilhelm Luther. The time-balls at Cuxhaven and Bremerhaven have worked satisfactorily, the former having failed only four times and the latter five. The Hambu g ball has given more trouble, having failed, from various causes, twenty-one times during the year.

Harvard College Observatory (1886).—The forty-first annual report of the director covers the year ending November 1, 1886. About half the Paine bequest, or $164,198, has become available for the support of the observatory; and the funds, which in 1875 amounted to $164,067 and in 1885 to $226,988, have now risen to $398,046. This increase must for

the present be devoted to the publication of observations already made, and to effecting repairs in the buildings and instruments. A new mounting for the 15-inch equatorial is required, and Professor Pickering expresses the hope that at no distant day means may be found for replacing the present building by one better adapted to the requirements of modern astronomy.

The most important extension of the work of the observatory which has recently been made is in the field of stellar photography. With the aid from the Bache fund almost the entire visible sky has been photographed, and a large number of photographs of stellar spectra have been obtained. For continuing the researches upon a stellar spectra Mrs. Draper has lent the 11-inch photographic lens employed by her husband, the late Dr. Henry Draper, and has provided means for a new mounting at Cambridge, and for the proper reduction and publication of the results. This investigation has been referred to under "Astronomical photography."

The 15-inch equatorial has been used for photometric observations, observations of new comets, and of the new stars in Andromeda and Orion, and for experiments in photography.

The work projected for the meridian circle is now completed, and the reductions are being pushed as rapidly as possible. Volume XV, part 1, containing the annual results for the fundamental stars, 1870–'79, and the individual results, 1883–'86, has been published; it includes also the results from the separate observations of stars belonging to various special classes, and the catalogue of 1,213 stars, separately issued in 1885. The second part of this volume will contain the catalogue of zone stars. Volume XVI (published) contains a tabular statement of the instrumental constants and a journal of the observations. A volume corresponding to volume XVI, but relating to the zone stars instead of the fundamental stars, and another, containing the observations for absolute right ascension and declination made from 1879 to 1883, will complete the work of the meridian circle still requiring publication. The resignation of Prof. William A. Rogers, who has had charge of this instrument since it was mounted in 1870, is greatly to be regretted. Professor Rogers has accepted the position of professor of astronomy at Colby University, Waterville, Maine, but will, however, superintend the reduction of his meridian observations and their publication.

The meridian photometer, Professor Pickering states, has given entire satisfaction, both in accuracy and in rapidity of work. (*See* Photometry.) A time-ball is dropped at the Boston post office, and the telegraphic announcement of important discoveries has been continued under the management of Mr. Ritchie. The report concludes with a list, embracing twenty two titles, of contributions to astronomical literature made by officers of the institution during the year.

The following financial statistics, some of which may be found in further detail in the report of the treasurer of the university, will be of interest:

Value of grounds, Harvard Observatory	$80,000
Value of buildings	25,000
Value of instruments	40,000
Endowment	398,000
Total	543,000

The available annual income, including gifts for immediate use, is $22,000. The salary of the director is $3,400, the use of the house being estimated at $600 more. The sale of time signals brought in nearly $3,000 during the year. The principal items of expenditure are—

Total expenditure for salaries, including that of director	$12,000
Total expenditure for instruments	800
Total expenditure for publications	3,500
Repairs and improvements on buildings and grounds	940

The personnel includes Professor Pickering, the director; assistant, Prof. W. A. Rogers (resigned September 1, 1886); assistant, Prof. A. Searle; and Messrs. Wendell, Edmands, Ritchie, Gerrish, Gifford, and Metcalf; with six computers, ladies.

The Boyden fund, which was left for the purpose of astronomical research "at such an elevation as to be free, so far as practicable, from the impediments to accurate observations which occur in the observatories now existing, owing to atmospheric influences," has been transferred to Harvard College and will be administered at the observatory. The fund at present exceeds $230,000. Professor Pickering proposes to establish an experimental observing station in Colorado, but desires to occupy ultimately some high mountain peak in the southern hemisphere where observations—largely photographic, probably—can be carried on in co-operation with Cambridge. Information in regard to eligible sites south of the equator is much desired.

Heidelberg (1886).—Private observatory of Dr. Wolf. The principal instrument is a 6-inch equatorial; objective by Reinfelder & Hertel, mounting by Sendtner, of Munich. A photograph of the observatory is given in Sirius, vol. 19, Heft 12.

Helsingfors (1885).—Dr. Donner has continued to observe the moon, moon-culminating stars, and planets, with the large transit instrument. This instrument is to be remodeled by Repsold into a meridian circle. A portable transit of 6.9^{cm} (2.7 inches) aperture by Repsold has been mounted in the prime vertical. The equatorial has been used for observing comets.

Herény (1885).—The mirror of the 10¼-inch reflector having been resilvered by Professor Safarik, the instrument has been arranged for experiments in celestial photography. Herr von Gothard has succeeded in photographing several constellations, star-clusters, nebulæ, and stellar spectra, but the work is still regarded as experimental. Spectro-

scopic observations and drawings of the planets have been continued as heretofore.

Hillsborough, Ohio.—Private observatory of Henry A. Pavey. Approximate position: Latitude, $+39° 12'$; longitude, $5^h 34^m$ west of Greenwich. The instruments are a 4-inch equatorial by Benjamin Pike's Sons, with mean-time clock and chronometer, and other accessories. Physical observations of the sun and Jupiter have been made, and observations of the zodiacal light. Variable stars have been observed in accordance with the plan proposed by Professor Pickering.

Kalocsa Observatory (1886).—Dr. C. Braun has published a report of the observatory founded by Cardinal Haynald, archbishop of Kalocsa. The instruments are a refractor, by Merz, of 7 inches; another of 4 inches; a transit, by Cooke, of 2.3 inches; altazimuth, clocks, spectroscopes, photometers, etc. The latitude from geodetic observations is $+46° 31' 41''.92$; astronomical methods give it $0''.07$ greater. The longitude is $1^h 15^m 54^s.343$ east of Greenwich. A valuable series of sunspot observations has been made and discussed.

Karlsruhe (1886).—The observatory at Karlsruhe (Baden) is still in a small, temporary, wooden building, the instruments having been removed in 1881 from Mannheim to the present quarters in Karlsruhe, where the observatory forms a part of the "Techniche Hochschule." Unfortunately the financial condition of the Grand Duchy of Baden has thus far precluded the establishment of a thoroughly equipped observatory, which has been in contemplation. The temporary building has two small meridian rooms, and a dome. The instruments are: (1) a 6 inch refractor by Steinheil, lately remounted by Fecker & Co., of Wetzlar; (2) an old repeating circle by Reichenbach some years ago changed into a meridian circle by Hildebrandt & Schramm, of Freiberg; the telescope has an aperture of 84 millimeters (3.3 inches); the divided circle is 3 feet in diameter; (3) a large portable transit instrument by Bamberg, of Berlin; (4) two fine clocks by Hohwii, of Amsterdam—one with break-circuit attachment; (5) chronographs, chronometers, etc.

The personnel consists, at present, of the director, one regular assistant, and a temporary assistant. The director, Dr. W. Valentiner, has begun with the meridian circle a series of observation of all stars down to the eighth magnitude between 0° and 20° of south declination, each star will be observed six times. So far about nine thousand observations have been made, and most of these have been reduced and published in parts 1 and 2 of the "Veröffentlichungen" of the observatory. The assistant, Dr. von Rebeur-Paschwitz, uses the refractor for observations of comets, occultations, etc.; his principal work is the micrometrical measurement of star-clusters; two groups will soon be finished. The filar micrometer has been carefully investigated. Herr von Rebeur has also completed an exhaustive discussion of comet 1882 I (Wells). The second assistant, Herr L. Stutz, makes regular observations with

the transit instrument for the time-service of the observatory, and also observes moon-culminations and right ascensions of the fundamental stars for the southern zones of the "Astronomische Gesellschaft."

Kew (1886).—The magnetical and meteorological observations and observations for time are kept up. Sketches of sun-spots projected on the photo-heliograph screen are made in order to continue Schwabe's enumeration.

Kiel (1885).—Observations with the meridian circle and equatorial are continued, the equatorial having been provided with a new registering apparatus. The catalogue founded on the Helsingfors Gotha zones is still unfinished.

Lawrence Observatory.—(*See* Amherst.)

Kis-Kartel (1886).—Private observatory of Baron Podmaniezky, near Budapest, Hungary. The principal instrument is a 7-inch refractor by Merz, with a mounting by Cooke. The work commences next year with double-star measures and physical observations of the sun, moon, and planets.

La Plata Observatory (1886).—The Government of the province of Buenos Aires is fitting up in La Plata an observatory which is to have a 31.5 inch reflector, an equatorial *coudé* of 17 inches, an 8-inch transit, a large Thollon spectroscope with objective of 9.8 inches, apparatus for celestial photography, and numerous smaller instruments. A time-service will be instituted, and a large amount of geodetic work will be done, including the measurement of an arc of a meridian. The observatory is to be under the direction of M. Beuf, late an officer in the French navy.

Leipzig (1885).—Dr. Harzer has gone to Pulkowa, and has been succeeded at Leipzig by Herr Schnauder. The zone observations and necessary reductions are being advanced as rapidly as possible. The equatorial has been used on comets and star-clusters.

Leyden Observatory (1885).—Prof. H. G. van de Sande Bakhuyzen's report is for the year ending September 15, 1885. The new 10½-inch equatorial, with objective by Clark, and mounting by Repsold, is ready for use. The 7-inch refractor was used for observations of comets. A series of measurements of artificial disks was made with Airy's double-image micrometer for the purpose of determining the systematic errors of the measures of the diameters of Mars and Uranus obtained in former years. The meridian circle was devoted to observations of fairly bright circumpolar stars. Some progress has been made with the reductions of the zone observations, 1874–'76.

Lick Observatory (1886).—The Lick Observatory will soon be counted as one of the active observatories of America. The formal opening and transfer to the University of California can not take place until the great telescope is mounted (probably in the summer of 1887), but Professor Holden already has one assistant at work—Mr. Keeler, who has been Professor Langley's assistant at Allegheny for a number of years.

The crown and flint lenses for the 36-inch objective arrived safely at Mount Hamilton on December 27, 1886, and have been packed away in a fire-proof vault in readiness for the mounting.

It is the intention to provide three lenses, the third a "photographic corrector" which can be slipped on in front of the other two. The Clarks found that the first piece of glass sent them for this lens showed signs of internal strain due to insufficient annealing, and the work of figuring was only undertaken at the risk of the makers, Feil & Co. The suspicion of strain proved well founded, for the disk burst into three pieces while upon the grinding tool. Another disk will be procured and should be ready by June 1, 1887. The cost of the objective was $52,000. The photographic lens will add several thousand dollars to this. The recent death of Feil père may cause serious delay in obtaining the glass for the third lens.

The mounting is under way in the workshops of Messrs. Warner & Swasey, of Cleveland, Ohio, and will be delivered at Mount Hamilton in June, 1887, for $42,000. It will contain many novel devices, among them an application of a modified form of the bicycle ball-bearings to the right ascension and declination axes, which will insure great ease of movement. The driving clock will have an electrical control.

The hemispherical dome of 70 feet interior diameter has been built by the Union Iron Works, of San Francisco, for $56,800. The question of an observing chair has been met by adopting Grubb's plan of moving the floor vertically 16 feet. Some such arrangement becomes absolutely necessary when we consider that the "spectroscopic length" of the telescope is some 5 feet more than the visual length, and the photographic length some 8 feet less; the eye-piece may be 7 feet from the base of the dome when the telescope is pointed to the zenith, or it may be 35 feet in the horizontal position. The floor will be raised in four minutes with a perfectly parallel motion, by hydraulic rams. The cost of the floor will be $14,500. A star spectroscope is to be made by Brashear, of Pittsburgh, for $1,000, and the micrometer by Fauth, of Washington, for $750.

The total cost of the observatory will be a little over $500,000, leaving nearly $200,000 available as a permanent endowment. The annual income of the observatory from all sources will be about $20,000.

In the summer of 1886 Prof. G. C. Comstock made an investigation of the Repsold meridian circle and a preliminary determination of the latitude. The resulting latitude of the north dome is $+ 37° 20' 25''.2$; the longitude given by the U. S. Coast Survey is $8^h\ 6^m\ 34^s.35$ west of Greenwich. A time service is in operation over the whole Pacific system of railways from Ogden to El Paso. Volume 1 of the observatory publications is in press, and will be distributed in the early summer.

Professor Holden's plan for utilizing to the utmost the magnificent equipment under his charge must commend itself to every one. The plan is to relinquish the use of the 36-inch equatorial for certain hours

of each day to distinguished astronomers, specialists, who may wish to turn its enormous power upon some one of the many unsolved problems of astronomy. Such astronomers may be invited to visit the observatory for periods of several months, and will be given every possible facility. The legislature of California has provided money for a permanent support of the observatory.

Lund (1885).—Dr. Dunér is principally occupied with stellar spectra and variable stars. Herr Laurin has observed with the meridian instrument a number of stars with large proper motion.

McCormick Observatory.—Professor Stone's report for the year ending June 1, 1886, states that the 26-inch equatorial has been employed chiefly in examining and sketching southern nebulæ. The nebula in Orion and the Trifid and Omega nebulæ have received special attention; many others have been studied, and two hundred and thirty-three new nebulæ have been discovered. "The features seen indicate that the performance of the instrument employed surpasses that of any of the great reflectors which have been used in the examination of nebulæ." Double stars, comets, and occultations by the moon have also been observed. Observations with the small equatorial for the revision of the 23° zone are now practically completed. Electric lamps are used for illuminating the circles and field of the great equatorial, and have proved most useful. The 45-foot dome revolves as easily as when first erected.

The cost of the observatory building and instruments was about $70,000, of which $64,000 was the gift of Leander J. McCormick. A working fund of $25,000 was given by William H. Vanderbilt, and an endowment of the directorship of $50,000 was subscribed by the alumni of the University of Virginia.

Professor Stone is assisted by Mr. F. P. Leavenworth and Mr. F. Muller. Part 2 of volume I, on the great comet of 1882, and part 3, on the nebula of Orion, have been issued during the year.

McGill College Observatory (1886).—A most thorough discussion of a series of longitude observations by Professor McLeod, at McGill College, and Professor Rogers, at Harvard College Observatory, has been published: the resulting longitude of the pier of the transit instrument at McGill Observatory being $4^h\ 54^m\ 18^s.543 \pm 0^s.043$ west of Greenwich. The center of the dome of the Harvard Observatory is assumed to be in longitude $4^h\ 44^m\ 30^s.993 \pm 0^s.041$ west of Greenwich.

Melbourne (1886).—Mr. Ellery has published the first installment of observations of southern nebulæ made with the great Melbourne reflector from 1869 to 1885. A description of the great 4-foot Cassegrainian reflector is given; and there are several lithographs of small nebulæ. Some fine results have been obtained in photography both of the moon and of stars and nebulæ.

Mexico. *See* Tacubaya.

Milan.—The 18-inch Merz-Repsold refractor was mounted and ready

for work in May, 1886. The 8-inch glass has been used for double stars, comets, etc. Messrs. Rajna, Porro, and Abetti have been engaged in geodetic work.

Morrison Observatory (1886).—The work of the equatorial for 1886 has consisted of a series of observations on comets Fabry, Barnard, and Finlay (reduced and published or ready for publication); physical observations of Jupiter and phenomena of Jupiter's satellites, with a few observations of occultations by the moon. The meridian circle can be used, at present, only for time observations and for the determination of such star-places as are needed in equatorial work. A daily and efficient time-service is maintained on railroads extending to St. Louis, Chicago, and Kansas City, and thence south and southwest. Meteorological observations are kept up with regularity.

Professor Pritchett has prepared a small volume of the unpublished observations of former years. This is now passing through the press, and will be distributed as soon as practicable. The expense of publication is borne by Mrs. Berenice Morrison-Fuller, the founder of the observatory.

The annual income of the observatory is $2,160. This covers all expenses, including salaries. The director has no assistance, except that rendered by his daughters, and such as is afforded by a boy in handling the instruments and caring for the rooms.

Munich (1885).—The revision of Lamont's catalogue is progressing favorably. A number of stars from the southern Durchmusterung have been added to the observing list, to fill up gaps. Dr. Seeliger has finished a count of the stars in this southern extension of the Durchmusterung similar to the one already published for stars of the northern hemisphere. Dr. Bauschinger was obliged to devote two months of the year to "Militärische Verpflichtungen."

Nice (1886).—The refractor of 30 inches was provisionally mounted in August, and it is stated that the trials with it have given most excellent results.

O'Gyalla (1885).—The main work of the observatory has been the experimental determination of the mechanical energy of the radiations of thirty-four stars of the first and second magnitude. The spectroscopic "Durchmusterung" of a zone 0° to 15° is nearly completed. Sun-spots are observed regularly.

Oxford University Observatory (1886).—Professor Pritchard's report was read to the board of visitors on June 16. The photometric measurement of the magnitudes of an equatorial zone of stars has been undertaken. Attention will be given to astronomical photography—a department of work for which the observatory is well equipped—directing investigations to, first, the relation which exists between the photometric and the photographic magnitude of stars; second, the reliable uniformity of the photographic film; third, the amount of astronomical accuracy attainable on the same.

Palermo (1885).—New comets, shooting stars, solar spots, and protuberances have been observed; drawings have been made of the planets, and atmospheric phenomena have been studied.

Paris (1885).—The report of Admiral Mouchez, presented to the council on the 22d of January, 1886, gives especial prominence to the work in astronomical photography. A reproduction is given of a photograph of the Pleiades taken by the Henry Brothers, and also an illustration of the instrument employed. We have already referred to many of the interesting results obtained. Three instruments have been used for photography; the first (aperture 6.3 inches), the experimental instrument used in 1884, has been employed in photometric researches. The second is a smaller instrument, aperture 4.3 inches, for photographing large comets and extended groups of stars. The third is the equatorial of 13 inches aperture, with which the more important work has been done.

The routine work has not, however, suffered; in the meridian service over sixteen thousand observations have been made by sixteen different observers; the instrument devised by M. Lœwy, the *equatorial coudé*, has been used for the observation of comets and minor planets, and the time-service, meteorological department, etc., are all in a most satisfactory condition. The reductions for the great catalogue were completed up to 8^h right ascension. The catalogue has been printed up to number 3,800.

Plonsk (1885).—Comets, double stars, etc., have been observed, and an interesting study of the atmospheric lines of the spectrum has been undertaken. Dr. Jedrzejewicz, the director, has made a new determination of the geographical co-ordinates of the observatory with the following result: Latitude, $+52° \ 37' \ 40''$; longitude, $27^m \ 57^s.07$ east of Berlin.

Potsdam (1885).—Dr. Vogel's most interesting report occupies more than ten pages of the Vierteljahrsschrift (vol. 21, pp. 132–142). The instruments have been improved in many minor details, and several pieces of subsidiary apparatus have been added. Drs. Müller and Kempf have devoted considerable time to finishing the new determination of wave-lengths of the Fraunhofer lines. Drs. Vogel and Wilsing have been at work upon the spectra of new stars, spectra of comets, and spectra of solar spots and protuberances. Dr. Müller has made a number of photometric observations of the major and minor planets, while Dr. Wilsing has observed variable stars. Dr. Lohse has made a series of drawings of Jupiter, and has obtained one hundred and forty-six photographs of the sun; these latter, taken in connection with Dr. Spoerer's telescopic observations, will furnish ample material for the history of the spots. Dr. Lohse has also continued his series of photographs of star-clusters with gratifying success. Dr. Wilsing has carried on a very interesting series of experiments to determine the density of the earth. The third part of volume four and the fifth volume of the

Annals have been published. The library has increased to about thirty-seven hundred volumes.

Prague (1885).—Professor Safarik has devoted his attention to variable stars.

Princeton (1886).—The 23-inch equatorial has been used by Professor Young in micrometrical work upon close double stars, the satellites of Uranus and Neptune, the surface markings of Jupiter, and the details of Saturn. Comets are observed when they have become difficult objects for smaller instruments. Occasional spectroscopic observations are made of sun-spots, prominences, and comets. The institution has no endowment which would make it possible to undertake any extensive or continuous programme of work. The small observatory is used almost entirely for instruction in practical astronomy, this part of the work being under the immediate supervision of Professor McNeill.

Pulkowa (1886).—The annual report of Dr. Struve is for the year ending May 25, 1886. The great routine work, the determination of star-positions, has been continued as in former years. The 30-inch refractor, in the hands of Dr. Hermann Struve, has been employed in observing the faint double stars of Burnham's catalogue, the satellites of Mars, Saturn, and Neptune, the Maia nebula and Nova Andromedæ, which was easily visible on January 27. Dr. Hermann Struve speaks in the highest terms of the instrument, both as regards its optical power and its mounting, the movement of the dome, etc. Backlund has measured with the 4-inch heliometer the positions of Jupiter's satellites, for a determination of the mass of the planet and the orbits of the satellites. Hasselberg has been experimenting upon photography of the solar spectrum. The observatory has met with a severe loss in the recent death of Herr Wagner.

Radcliffe Observatory (1886).—Observations have been made of the sun, the moon throughout the lunation, occultations by the moon, and the phenomena of Jupiter's satellites. Volume 41, containing results for 1883, has been published.

Rio Janeiro (1886).—M. Cruls announces that the observatory is to be transferred to a new site, nearly on the same parallel as the present observatory, but two minutes of time farther west. M. Cruls has been commissioned by the Emperor of Brazil to have a photographic apparatus constructed similar to that at Paris, in order to co-operate in the proposed photographic survey of the heavens.

Rousdon (1886).—A private observatory erected in 1884 and 1885 by Mr. Cuthbert E. Peek at Rousdon, near Lyme Regis, Devon, England. The principal instruments are, a 6.4-inch equatorial objective by Merz, mounting by Cooke, a 2 inch Troughton & Simms transit, chronometers, etc. Beneath the equatorial room is a laboratory which is also fitted for photography. In 1886 the comets of the year and a list of long-period variables were observed, and transit observations were made for rating the chronometers. A volume containing observations of comets,

Nova Andromedæ, etc., and meteorological observations from 1882 to 1885 has been published.

Smith College Observatory.—Professor Todd includes in his report of the Amherst Observatory a brief account of an observatory, the construction of which he has supervised for the trustees of Smith College (for young women), at Northampton, Massachusetts. A one-story brick building is divided into an equatorial room, photographic dark-room, library, clock-room, and transit-room. The equatorial is of 11 inches aperture, the objective by the Clarks, and mounting by Warner & Swasey. Incandescent lamps are provided for the illumination of the circles and micrometers. The transit-room will contain a 4-inch meridian circle. The approximate position of the new observatory is: Latitude, + 42° 19′ 7″; longitude, $4^h\ 50^m\ 32^s.9$ west of Greenwich.

South Evanston (1886).—Dr. Marshall D. Ewell has erected a small private observatory at South Evanston, Cook County, Illinois, 10.8 miles north of Chicago. The equatorial is a 6½-inch Clark refractor mounted on a pier made of Portland cement and fine gravel so as to form practically a single piece of rock from top to bottom. The dome is 12 feet in diameter, built with ash ribs covered with tin, and turns on six iron wheels. The observatory is also provided with a 2¼ inch Troughton & Simms transit, sidereal and mean-time chronometers, and minor apparatus.

Stockholm (1885).—Investigations upon the motions of the different members of the solar system have absorbed the attention of the director and his assistants. The mean motions of the apsides of the planets Jupiter, Saturn, and Uranus are found to differ sensibly from the values assigned by Leverrier. Herr Shdanow has continued Gyldén's researches upon the lunar theory, and Dr. Harzer has contributed a valuable memoir upon the motion of Hecuba.

Strassburg.—Dr. Schur, previous to his departure for Göttingen, where he takes Klinkerfues' place, published a report, dated May 6, 1886, supplementary to his annual report of July, 1885. The principal meridian work was upon southern stars in the extension of the Durchmusterung, and Auwers' eighty-three southern fundamental stars and refraction stars. The moon was observed with the altazimuth; comets with the refractor. Dr. Kobold succeeds Herr Schur. Dr. Winnecke has been retired, at his own request, on account of ill health.

Tacubaya (1885).—The Observatorio Nacional, formerly at Chapultepec, is now at Tacubaya, about 6 miles from the city of Mexico. The final value of the longitude of the large meridian circle, from exchanges in 1885 with St. Louis, is $6^h\ 36^m\ 46^s.54 \pm 0^s.02$ west of Greenwich. (Astron. Jour., 7 : 62.)

Taschkent (1885).—The refractor was employed principally in observing sun-spots; comets and occultations were also observed. The meridian circle furnished the places of a number of comparison stars for

comets and planets. Geographical positions were determined for six towns in central Asia.

Temple Observatory (1886).—Observations of double stars have been continued, and spectroscopic observations to determine the motion of stars in the line of sight.

United States Naval Observatory (1886).—No material change has been made in the character of the work. Professor Hall has used the 26 inch refractor in observations of Saturn, of double stars, and of satellites; and also for determinations of stellar parallax. No deterioration of the objective has been noticed since it was repolished ten years ago.

The transit circle has been employed in observations of the sun, moon, planets, and such stars as are necessary to complete the data for a transit-circle catalogue, which will contain all of the miscellaneous stars observed since the instrument was mounted, twenty years ago. The reductions are somewhat behindhand on account or the inadequate computing force. The 9.6 inch equatorial has been used in the observation of comets, asteroids, and the occultation of stars by the moon; and the Repsold meridian circle at Annapolis temporarily, under the direction of the Superintendent of the Washington Observatory, in the observation of a list of southern stars. The revision of Yarnall's catalogue and the reduction of recent observations with the prime vertical instrument are progressing favorably. Photographs of the sun have been taken with the photo-heliograph used during the transit of Venus. Ninety-eight negatives showing spots were secured between January 11 and September 30, 1886.

The extensive time-service of the observatory is in an efficient state, and the chronometer tests inaugurated a few years ago have proved of great benefit to the naval service. Considerable attention has also been given to the examination of nautical instruments, thermometers, etc., for the Navy.

The volume for 1882, and Appendices I, II, and III to the volume for 1883 have been distributed.

Commodore Belknap was relieved from duty as Superintendent on June 7, 1886, by Commander A. D. Brown, and Commander Brown on November 15 by Capt. Robert L. Phythian.

The expenses of the observatory are met by annual appropriations from Congress, the naval officers (including professors) receiving the pay of their respective ranks. The pay of fourteen officers attached to the observatory December 1, 1886, aggregated $31,400.

The specific appropriation for the observatory for the year ending June 30, 1886, contains the following items: For pay of three assistant astronomers, $5,600; one clerk, $1,800; instrument maker, $1,500; four watchmen. $4,880; assistant for the 26-inch equatorial, $720; gardener, $1,000; seven laborers, $4,620; for miscellaneous computations, $1,200; purchase of apparatus and material for repairs of instruments, $2,500;

library, $1,000; repairs to buildings, fuel, gas, furniture, stationery, and contingent expenses, $3,900; freight on observatory publications sent to foreign countries, $366. The entire annual cost of the maintenance of the observatory may, therefore, be put at about $58,500;—$50,700 being for salaries and wages, and nearly $7,800 for other expenses. The item of salaries will vary considerably, of course, with the number and rank of line officers on duty, and it should be borne in mind that several of the officers are engaged upon work carried on at the observatory as a naval institution.

The sum of $100,000 is now available for the erection of a new observatory, and the plans prepared six or eight years ago are being revised, with a prospect of beginning work upon the new buildings in the course of a few months. The total cost of the buildings is limited to $400,000.

Warner Observatory.—Dr. Swift has confined himself to the discovery of new nebulæ and the search for comets. The instruments are: A 16-inch Clark equatorial, provided with a filar micrometer and many convenient accessories; a 4½-inch comet-seeker, and a sidereal clock by Howard. A spectroscope, to cost $1,000, has been ordered from Alvan Clark & Sons. A description of the observatóry, with its instruments and work from 1883 to 1886, has been published as volume I of the observatory publications. This volume contains a list of four hundred and nine nebulæ discovered since July 9, 1883 (it is stated that five hundred and forty have been discovered in all), a list of the Warner astronomical prizes, and the full text of the Warner prize essays on comets and on the red "sky-glows."

Vanderbilt University Observatory, Nashville, Tenn.—This observatory is supplied with the following instruments:

Six-inch equatorial refractor, by T. Cooke & Sons, 8-foot focus, with hour circle divided to single minutes, and subdivided to 2^s by opposite verniers; and declination circle divided to $10'$ and read by two verniers to $10''$. There is also a third vernier reading to $15''$, used for setting in declination, and read by the observer at the eye-piece with a small telescope. The instrument is supplied with eight eye-pieces, ranging from 60 to 600, and filar micrometer (bright field, dark wires only). A revolving disk with colored glasses gives a change of color of field,—a red one being found most useful, as it seems to permit observations of fainter objects with sufficient distinctness of the wires. A ring micrometer (not belonging to the observatory) is also used with the equatorial. A good driving clock gives a steady motion to the telescope. Two spectroscopes belong to this instrument—one, a direct-vision spectroscope by Merz & Mahler, the other by Grubb.

The equatorial room is surmounted by a hemispherical dome, revolving readily by hand on twelve pairs of wheels. The shutter is of light corrugated iron, in two sections; the upper section, two-thirds of the entire length, passes through the zenith to the back of the dome; the other part is drawn to one side, running on two light wheels, upon

a projecting platform. This instrument has been used during the past year in the observation of comets, nebulæ, and the planets, and other miscellaneous work. Positions of all the comets have been obtained with either the ring or filar micrometer. Some experiments in celestial photography have been carried on, and good views of the moon obtained. The instrument cost about $1,900.

A 4-inch meridian circle, by Ertel, with circles 26 inches in diameter, divided to 3′. On the east pier is mounted a frame carrying four microscopes which read the circle to 0″.5. The reticule consists of thirteen vertical and two horizontal wires. The field or threads are illuminated at will. This instrument is reversible, and cost about $1,400.

The chronograph is one of Warner & Swazey's latest designs, and is used with either the equatorial or meridian circle. Cost, $375. The sidereal clock, by Dent, cost $500. The mean time clock, by Howard, cost $400.

There is also a 3-inch altazimuth, by Cooke; and a 5-inch portable refractor, by Byrne. This latter instrument is not the property of the observatory. With it Professor Barnard has discovered a large number of comets.

The observatory building consists of a transit room, an equatorial room, and two computing rooms. The equatorial room is on the second floor, and is reached by a spiral staircase.

Washburn Observatory (1886).—This fine observatory possesses a 15½-inch Clark equatorial, with filar micrometer, a Repsold meridian circle, one sidereal and two mean-time clocks, a chronograph, chronometers, etc., besides the excellent 6-inch equatorial which formerly belonged to Mr. S. W. Burnham, and with which his first observations and measurements of double stars were made. This latter equatorial, together with a Fauth 3-inch transit, is mounted in a separate building of wood, called the students' observatory. The main building has, besides the rooms for the meridian circle and the large dome for the equatorial, a separate clock and computing room, a room for the electrical switch-board, time relays, etc., and a well furnished room for a library and director's study. There are also sleeping rooms for two assistants, one of whom is the meteorological observer whose records are printed in the annaal volumes of the observatory. The officers of the observatory are a director, two assistant astromoners (one of whom is a lady), the meteorological observer, and a janitor. The library of the observatory is maintained by the generosity of the Hon. Cyrus Woodman, of Cambridge, Massachusetts, who has given, for this purpose, the sum of $5,000. One half the yearly interest from this sum is available for the purchase of new books, the other half going to increase the principal until it reaches a specified sum. The "publications" are printed at the expense of the State, and are issued when circumstances warrant. Four volumes have already been issued, and a fifth is nearly ready for publication.

The entire outfit of the observatory, in instruments and buildings, is due to the munificence of the late Governor Cadwallader C. Washburn, and cost not far from $50,000. A detailed list of the cost of some of the instruments is given in the volumes of publications of the observatory. All salaries and running expenses are paid by the regents of the university from the general fund. These have heretofore amounted to about $5,000 annually.

After the departure of Professor Holden, in December, 1885, the assistants of the observatory, Mr. Milton Updegraff and Miss Alice Lamb, completed the observations and reductions of the three hundred and three star list, and the reading of the proof-sheets for the publication of volume IV (1885) of the observatory reports. During the early summer of 1866 a careful study of the division errors of special diameters of the meridian circle was undertaken; also of its horizontal flexure. Observations of the latitude made with the meridian circle since its first mounting show a discordance between circle east and circle west of about 1″. The cause of this is now an object of study, and is believed to be mainly due to flexure. The large equatorial has been kept employed upon double stars, and in January, 1887, a series of measurements was made with its filar micrometer upon the position of Sappho (80) at opposition. An index to those stars in the six Greenwich catalogues not occurring in Flamsteed, has been prepared by Miss Lamb, and will be published in volume V.

The usual routine work of the observatory, such as controlling the clocks in the city of Madison, the time bells in the university recitation rooms, and the daily furnishing of time-signals to the railroads entering Madison, has been faithfully attended to. Professor Holden's successor as director of the observatory is Prof. John E. Davies.

Washington University Observatory, St. Louis (1886).—Instruction in theoretical and practical astronomy is the main object of the observatory. An extensive time-service is maintained, and the observatory co-operates with Government field parties in geodetic work. Prof. H. S. Pritchett has one assistant. The income is derived from the general university endowment and from the time-service.

Woodside Observatory.—Mr. Charles L. Woodside has a small private observatory at East Boston, Massachusetts, its approximate position being latitude $+42^\circ\ 22'\ 39''$; longitude $4^h\ 44^m\ 9^s$ west of Greenwich. The principal instrument is a silvered-glass reflector of 6½ inches aperture and 5 feet focal length; the mirror is by Brashear, of Allegheny, and the mounting by Mr. Woodside himself. This is to be devoted for several years to a careful and systematic study of the colors of all stars brighter than the sixth magnitude visible at Boston. Mr. Woodside has devised a method of computing occultations which he has described in the Sidereal Messenger for July, 1886.

Yale College Observatory (1886).—For the year ending June 1, 1886, Dr. Elkin reports progress in his work of triangulation in the Pleiades

with the 6-inch heliometer. He proposes to observe ten of the brightest stars in the northern hemisphere for parallax. Mr. A. Hall, jr., has been engaged in observations of Titan with the heliometer, with a view to a new determination of the mass of Saturn.

Zürich (1885).—Dr. Rudolf Wolf is occupied almost entirely with sun-spot statistics. He fixes the last "maximum" of spots at 1883.9.

ASTRONOMICAL INSTRUMENTS.

Barometer coefficients for clocks.—Dr. Hilfiker has determined the barometric coefficient—or the variation in rate for a change of 1 millimeter in the atmospheric pressure—for a Winnerl clock with gridiron pendulum comparing the Winnerl clock with the Hipp normal electric clock at Neuchâtel on each night of observation.

These comparisons, made between August, 1884, and September, 1885, give an idea of the influence of the mode of compensation upon the value of the barometric coefficient. The following table shows the results obtained at Geneva and at several other observatories for their normal clocks:

Place.	Compensation.	Barometric coefficient.
Neuchâtel	Winnerl, gridiron pendulum	$0^s.010$
Do	Hipp electric clock	0.012
Pulkowa	Mercury compensation	0.013
Leyden	do	0.015
Berlin	do	0.015
Zürich	do	0.015
Washburn Observatory	do	0.012

(Bull. astron., December, 1886.

The new optical glass.—Nature for October 28, 1886, contains an interesting account of the experiments of Professor Abbé and Dr. Schott in their endeavors to produce a glass of such chemical composition that it may be possible to make lenses free from the secondary chromatic aberration and other defects. For the microscope lenses already made of the new glass Professor Abbé claims great superiority in many important respects.

Electric illumination.—Prof. Ormond Stone, of the McCormick Observatory, uses for illuminating the circles and micrometer wires of the great equatorial, Edison incandescent lamps of one-candle power, run by what is known as the "Orne motor battery," or by the "Edco battery," the latter being used where a more continuous light is required. The success of the experiment here has resulted in the use of electricity, at least for circle illumination, at West Point, Yale and other observatories.

In the Greenwich spectroscopic observations, "a slip of metal coated

with Balmain's luminous paint, inserted immediately behind the measuring pointer, has been frequently employed to give a phosphorescent illumination of the field."

Gautier's mercury-basin for nadir and reflection observations, described in last year's report, has been tried at the Melbourne Observatory, and gives highly satisfactory results.

We have already referred, in the report of the Lick Observatory, to the completion of the 36-inch objective and its removal to Mount Hamilton.

MISCELLANEOUS.

Astronomical prizes.—At the meeting of the Paris Academy of Science on December 27, 1888, the Lalande prize was awarded to Dr. Backlund for his work on Encke's comet; the Valz prize to M. G. Bigourdan for investigation of personal equation in the measurement of double stars; the Damoiseau prize to M. Souillart for his theoretical researches on Jupiter's satellites, and an "*encouragement*" of 1,000 francs to M. Obrecht for his study of the application of photometry to the eclipses of Jupiter's satellites. The Bordin prize was awarded to M. R. Radau for his work on the theory of astronomical refraction.

The gold medal of the Royal Astronomical Society was awarded to Mr. G. W. Hill for his researches on the motion of the moon.

The Rumford medal of the Royal Society, the Rumford gold and silver medals of the American Academy of Arts and Sciences, and the Draper medal of the National Academy were awarded to Prof. S. P. Langley for his researches with the bolometer.

The Watson medal of the National Academy, with an honorarium of $100, was awarded to Dr. B. A. Gould.

The Royal Society of Edinburgh awarded the Makdougall-Brisbane prize to Dr. Edward Sang for his communication on the need for decimal subdivisions in astronomy and navigation.

The Warner prizes, $100 for each comet discovered (and announced under certain conditions), were conferred, in 1886, as follows: Mr. Brooks, $300; Mr. Finlay, $100; Mr. Barnard, $100.

The American Astronomical Society of Brooklyn.—Among the papers read in 1886 were: "The Earth's Temperature," by H. M. Parkhurst; "Faye's Nebular Speculations," by G. P. Serviss; "Origin of Meteorites," by G. W. Coakley and H. M. Parkhurst. The president of the society is Mr. S. V. White, the secretary, Mr. G. P. Serviss, Brooklyn, New York.

Baltimore Amateur Astronomical Society.—A number of gentlemen of Baltimore have organized an amateur astronomical society, meeting each month for the presentation of papers and discussion of observations. Dr. Hooper, 1425 Linden avenue, the secretary, has a 5-inch Clark equatorial; Mr. Gildersleeve a 6 inch equatorial with object-glass by Dr. C. S. Hastings; Mr. Stahn a 4 inch glass, also by Dr.

Hastings, and Mr. Numsen a 4-inch Cooke equatorial, mentioned in the report last year under the "Denmore Observatory." Physical observations are made of the sun, moon, planets, and comets. Mr. Stahn has kept a record of sun-spots, and has devised numerous ingenious accessories for his instruments.

Astronomical Journals.—The re issue of the "Astronomical Journal" by Dr. Gould is cordially welcomed, particularly by American astronomers, who are thereby furnished with a more prompt means of intercommunication than has been heretofore available. An interval of twenty-five years occurs after No. 144; and No. 145, bearing the date of November 2, 1886, begins volume VII. The Journal is edited by Dr. Gould, as before, at Cambridge, Massachusetts.

A new monthly astronomical review, Revista do Observatorio, has appeared, under the editorship of Dr. Luis Cruls, of the Imperial Observatory of Rio Janeiro. The journal will be found interesting and valuable by amateurs and those interested in the progress of astronomy, as well as by professional astronomers.

We are at the same time obliged to record the discontinuance of the Astronomical Register, with the completion of its twenty-fourth volume, December, 1886, No. 288.

The Influence of astigmatism on Astronomical Observations.—It appears from Professor Seeliger's researches that this malformation in the eye, which is far from uncommon, exerts a greater influence on astronomical measurements than is generally supposed. Thus, he shows that a systematic error in a series of observed declinations amounting to $0''.26$ may very well be due to it; and it appears that the discordances in observed position angles of double stars—depending on the inclination of the line joining the components to the vertical—with which the measures of some observers are affected, may be referred to the same cause. (Nature, November 18, 1886.)

Determination of time.—Döllen has described in the Nachrichten (114: 289) an expeditious method of obtaining a clock correction where great refinement is not necessary. The observation is made in the vertical of the pole-star, and tables have been published by the Pulkowa Observatory giving for some sixty odd stars all the quantities which are independent of the latitude, required in the formulæ. The work of reduction is made as brief as possible.

An astronomical directory.—M. A. Lancaster, the librarian of the Brussels Observatory, has published a very useful list of observatories, their geographical co-ordinates, and the astronomers attached to them; of astronomical societies and institutions, and of reviews and journals specially devoted to astronomy. The little book contains also a list of names and addresses of astronomers not attached to any observatory, and of amateurs, as well as a list of makers of astronomical instruments.

Miss Clerke's admirable "Popular History of Astronomy during the

Nineteenth Century" has been so widely reviewed that it seems unnecessary to do more than merely to mention it by title here. The book is "untechnical," and the "terse and vigorous" style makes it most interesting from beginning to end. There are numerous references to the original sources of information.

Professor Young's "Ten Years' Progress in Astronomy" has been reprinted in the Sidereal Messenger (vol. 6) and Nature (vol. 35).

ASTRONOMICAL BIBLIOGRAPHY, 1886.

The following bibliography is arranged by subjects, and contains journal articles and reprints from transactions of societies, as well as more formal publications. No pretense is made to completeness, even to the extent of including all titles that have come under the compiler's notice, and, in some cases, where it has not been possible to examine the publications themselves, the imprints, etc., may be imperfect. The prices quoted are generally taken from Friedländer's Naturæ Novitates, in German "mark" (1 mark = 100 pfennige = 1 franc 25 centimes = 25 cents, nearly).

It is hoped that the abbreviated titles of journals will be intelligible without special explanation. ("Compt. Rend." is, of course, the Comptes rendus hebdomadaires des séances de l'Académie des sciences, Paris, and "Month. Not." the Monthly Notices of the Royal Astronomical Society.) Among the imprint and other abbreviations there occur:

Bd. = Band.	n. F. = neue Folge.
d. = die, der, del, etc.	n. s. = new series.
ed. = edition.	p. = page.
hrsg. = herausgegeben.	p* = page of this summary.
il. = illustrated.	pl. = plates.
k. k. = kaiserlich königlich.	pt. = part.
Lfg. = Lieferung.	Rev. = Review.
M. = mark.	s. = series.
n. d. = no date.	sh. = shilling.
n. p. = no place of publication.	v. = volume.

The alphabetical arrangement is made to serve as an index to the present record, by inserting after the subject-heading, the pages of this review (p*—) on which the different subjects are noticed.

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AUERBACH (CARL HEINRICH, AUGUST); b. February 24, 1813, at Berlin; d. at Gohlis, October 22, 1886, æt 73.

BASSNETT (THOMAS); d. February 26, 1887, æt. 79.

BOILEAU (Gen. J. T.); b. May 26, 1805, at Calcutta; d. November 9, 1886, æt. 81.

DORNA (ALESSANDRO), director of the Turin Observatory; b. February 13, 1825, at Asti; d. at Borgo San Pietro, near Turin, August 19, 1886, æt. 61.

FELDKIRCHNER (CHRISTOPH), first assistant at the Munich Observatory; b. February 26, 1823; d. March 1, 1886, æt. 63.

HOÜEL (JULES), professor of mathematics at Bordeaux; b. ——, 1823, at Thaon; d. June 14, 1886, at Périers, æt. 63.

KRAPOTKIN (ALEXANDER); b. ——; d. at Tomsk, August 6, 1886, æt. 45.

MAYWALD (GUSTAV ADOLPH RICHARD), computer on the Berliner Jahrbuch; b. February 13, 1817, at Leuthen; d. July 19, 1886, æt. 69.

von Oppolzer (Theodor); b. October 26, 1841, at Prague; d. December 26, 1886, at Vienna, æt. 45.

Pearson (*Rev.* James); b. 1826, at Preston, England; d. April 8, 1886, at Fleetwood, æt. 60.

Saxby (*Rev.* Stephen Henry); b. ——, 1831; d. August 5, 1886, æt. 55.

Talmage (Charles George), director Leyton Observatory, b. November 12, 1840, at Greenwich; d. March 20, 1886, at Knots Green, Leyton, æt. 45.

Wagner (August), vice-director Pulkowa Observatory, b. September 10, 1828, at Nurft; d. at Pulkowa, November 14, 1886, æt. 58.